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ABSTRACT

Abstracts of research papers in computer and information science are given for 62 papers in the areas of information storage and retrieval; computer facilities; information analysis; linguistics analysis; artificial intelligence; information processes in physical, biological, and social systems; mathematical techniques; systems programming; computer architecture and networks; and computation theory. The Ohio State University Computer and Information Science Research Center is described. Abstracts are indexed by subject and investigator. (KP)

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ABSTRACTS OF RESEARCH

JULY 1975 - JUNE 1976

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The Computer and Information Science Research Center

The Ohio State University

Columbus, Ohio 43210

FOREWORD

The Computer and Information Science Research Center at The Ohio State University is a research organization which consists primarily of faculty, staff and graduate students of the Department of Computer and Information Science. Some of the research activities are performed in conjunction with other University departments as well as off-campus organizations.

This publication contains the abstracts of research which has been carried on during the 1975-76 academic year. This research has been supported in part by grants from governmental agencies as well as by The Ohio State University. Sponsorship with government agencies and with other units on the campus is identified at the end of an abstract.

A bibliography of the research reports published by the Center is included in this publication as Appendix F. Copies of some of these reports are still available on a complimentary basis from the Computer and Information Science Research Center, The Ohio State University, 2036 Neil Avenue Mall, Columbus, Ohio, 43210. Titles with PB or AD numbers may be obtained from The National Technical Information Center, The U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia, 22151, in paper copy, magnetic tape, or microfiche. There is a nominal charge for their service.

Marshall C. Yovits
Director, Computer and
Information Science Research Center

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I. THE OHIO STATE UNIVERSITY COMPUTER AND INFORMATION SCIENCE RESEARCH CENTER

ORGANIZATIONAL STRUCTURE

The Computer and Information Science Research Center at The Ohio State University is an interdisciplinary activity involving the faculty, staff and graduate students from the Department of Computer and Information Science. Some of the research activities are performed in conjunction with other University departments as well as off-campus organizations. The Center also interacts closely with Battelle Memorial Institute, Chemical Abstracts Service, and the Ohio College Library Center, which are adjacent to the Ohio State Campus, as well as with a number of other organizations located in Columbus, Ohio which are engaged in computer and information science research activities, such as Bell Laboratories, Western Electric Corporation, and Rockwell International Corporation. Although the Research Center and the Department utilize many of the same personnel and have the same Director, they are two separate and distinct entities.

OBJECTIVES OF THE CENTER

The Computer and Information Science Research Center has the following objectives: (1) to develop a broad research program in computer and information science; (2) to develop, test, and evaluate practical applications of research in computer and information science; (3) to coordinate and integrate these functions with an academic program in computer and information science at The Ohio State University, as well as with other disciplines at the University. The Center is a focal point for a number of applied information processing activities on the campus.

SCOPE OF THE PROGRAM

The program in computer and information science at The Ohio State University has been defined broadly to encompass most of the analytical activities frequently considered to be part of this discipline. This approach has been chosen because it is felt that in order to generate the needed concepts, foundations, and generalized techniques, it is necessary to examine analytically a number of different areas of computer and information science. In this way a firm empirical and theoretical foundation may be established for generalized computer and information systems. Such a view commits the program not only to the theoretical study of computer and information systems, but also to the study of their realization and their impact on the user.

Those areas of study which are emphasized both in the academic program and in the research activities of the Center are as follows:

1. General theory of information
2. Information storage and retrieval
3. Theory of automata and theory of computation
4. Artificial intelligence
5. Pattern recognition
6. Computer programming, including systems programming
7. Theory and processing of programming languages
8. Digital computer architecture and organization
9. Numerical analysis
10. Man-machine interaction and systems
11. Formal and computational linguistics
12. Management information and systems
13. Biological information processing
14. Social, economic, and psychological aspects of information production, processing, and use.

FACILITIES

The Computer and Information Science Research Center has a Digital Equipment Corporation DEC System-10 computer. It is a moderate size flexible time-sharing computer which is dedicated to research and education in the field of computer and information science. This computer provides valuable hands-on experience for the faculty and students of the Computer and Information Science Research Center and permits research activities involving non-standard and innovative applications of computers of both a hardware and software nature. Some of these research activities which are currently underway are:

1) Experimental and developmental research in time-sharing and multiprogramming systems.
2) Complex systems simulation research using graphical display devices.
3) On-line information retrieval systems studies.
4) Hardware modification and interface studies.
5) Software modification and development (e.g., PL/1 and COBOL compilers).
6) Man-machine interaction and psychophysical experiments.
7) Pattern recognition studies.
8) Computer simulation of language learning.
9) Speech analysis and synthesis.
10) Analysis and synthesis of human locomotion.
11) Computer data base systems.

The Research Center also has access to the University Computer Centers. They are: Instruction and Research Computer Center; Hospital Computer Center; and University Systems Computer Center.

Included in these centers are an IBM 370/168, two IBM 370/158, an IBM 1620 for plotting, and an IBM 7 and Bendix Data Grid Digitizer for analog to digital

conversion, as well as several IBM 1130 machines, and a number of remote terminals.

Many specialized facilities and laboratories of the University are also available to the staff and students of the Research Center. Some of these are the Office of Computer Assisted Instruction, the Institute for Research in Vision, Telecommunications Center, Behavioral Science Laboratory, Listening Center, Communications and Control Systems Laboratory, Mershon Center for Education in National Security, and many others.

The Research Center also interacts with the Ohio College Library Center which is administratively independent of the University. The Center was formed by the Ohio College Association in 1967 and operates a shared computerized library network connecting academic, public and school libraries in 39 states. This system has over 1200 specially designed CRT terminals in over 750 institutions that participate on-line. Two well established national information systems have units on the campus of The Ohio State University. The MEDLINE system is an automated on-line service to access medical journals of the previous three year period. The ERIC (Educational Research Information Center) system is an automated batch system to access research reports and journal literature in the field of education. These systems are available to the staff and students. Interaction has also been initiated with The Academy for Contemporary Problems.

The University has established a university-centered-information system. The information system, called the Mechanized Information Center (MIC) operates as a department of the University Libraries. MIC has developed a multi-disciplinary batch-mode information system from machine-readable data bases, primarily for the campus community. The interface to the MIC system is decentralized as much as possible through the existing system of twenty-three libraries around the campus which serve specialized publics. MIC acquires data bases from commercial sources, as well as from professional societies and governmental agencies. Research activities in MIC are directed toward improving the services of MIC to its users through software refinement and development.

MIC provides two basic types of services:

1) computer-based current awareness to help people keep up-to-date with current publications, and

2) computer-based retrospective searches to bring people up-to-date with previously published information.

There are three current awareness services:

1) science, including technology and medicine;

2) social sciences; and

3) education.

Retrospective services in the same disciplines are also available. For each of the services, specific data bases are searched to select bibliographic citations that are pertinent to a person's interests. MIC now provides current awareness searches to more than 3,500 people and organizations and has performed more than 25,000 retrospective searches.

ACADEMIC PROGRAMS IN COMPUTER AND INFORMATION SCIENCE

The program at The Ohio State University emphasizes education, research and the professional practice and application of computer and information science. The academic program is offered within the Department of Computer and Information Science and encompasses undergraduate and graduate degrees through the Ph.D. Statistics showing the growth of the department are found in Table 1.

Organization of The Department of Computer and Information Science

The Department of Computer and Information Science is a separate academic unit located administratively in the College of Engineering, operating in part as an interdisciplinary program with the cooperation of many other departments and colleges throughout the University.

Objectives of The Department

The program at The Ohio State University emphasizes education, research and the professional practice and application of computer and information science. The educational program offers undergraduate and graduate degrees through the Ph.D. The research activities which are a central part of the program consist of a broad conceptual base supported by a number of contracts and grants as well as by the university. The broad core research program and these other research tasks interact to form an integrated framework.

Undergraduate Programs

Undergraduate degrees in computer and information science are available to students in the College of Engineering, the College of Mathematics and Physical Sciences of the College of the Arts and Sciences, and the College of Administrative Sciences. The particular program chosen depends upon the student's interests and career objectives.

The undergraduate program in the College of Engineering leads to the degree of Bachelor of Science in Computer and Information Science. This program is designed for the student who wants to specialize in computer and information science from within an engineering environment. Hence, the program provides the student with a core of computer and information science, mathematics, and engineering science Both depth and breadth in computer and information science, are assured by specific required course sequences in several areas of engineering and science yet, sufficient flexibility exists so that a student can elect a portion of his technical course work in order to develop his individual interests.

There are two undergraduate programs in the College of Mathematics and Physical Sciences. These programs lead either to the degree of Bachelor of Science or the degree of Bachelor of Arts with a major in computer and information science. The programs are cast in a liberal arts setting and are similar in content. The Bachelor of Science program provides a somewhat more technical and thorough education in computer and information science and mathematics while the Bachelor of Arts program is somewhat more flexible and provides an opportunity to relate computer and information science to some other discipline.

Table 1: Growth of Department of Computer and Information Science

	SEPT'67	SEPT'68	SEPT'69	SEPT'70	SEPT'71	SEPT'72	SEPT'73	SEPT'74	SEPT'75	SEPT'76
A. Staff										
1. Full Time	5	11	14	15	18	18	18	20	21	22
2. Part Time	5	9	10	11	12	14	16	12	12	12
B. Graduate Students	32	89	114	151	165	187	209	198	201	194 (est)
C. Undergraduate Students	100	143	300	485	576	450	510	475	450	470 (est)
D. Course Enrollment (Autumn Quarter)	542	770	1059	1293	1447	1676	1728	1925	2098	2250 (est)

	'67-'68	'68-'69	'69-'70	'70-'71	'71-'72	'72-'73	'73-'74	'74-'75	'75-'76	'76-'77
Students Taught	1977	2892	3933	4703	5174	5600	6129	6876	7241	7690 (est)
M.S. Degree Awarded	7	17	35	44	47	49	67	58	64	59 (est)
Ph.D. Degrees Awarded					4	8	4	7	13	16 (est)
Applications for Graduate Study	181	190	343	425	400	323	290	355	325	
Number of Graduate Students Supported	27	72	78	88	89	83	78	81	77	

The undergraduate program in the College of Administrative Science leads to the degree of Bachelor of Science in Business Administration with a major in computer and information science. This program is designed for the student that is business oriented and desires an education in computer and information science and a general education in the administrative sciences. The program's objective is not to make a computer specialist out of a student, but rather to enable him to recognize the opportunities to use the computer in his managerial activities, to know what to expect from it, and to know how to communicate effectively with computer specialists so that computerized projects will be properly handled from a technical as well as a managerial point of view.

Graduate Programs

The Department of Computer and Information Science offers graduate programs leading to both the Master's and Ph.D. degrees. The graduate program leading to the Master's Degree is available in seven options.

Option I for the student desiring a theoretical foundation in computer and information science.

Option II for the student specializing in information systems.

Option III for the student specializing in computer systems.

Option IV for the student specializing in numerical analysis.

Option V for the student specializing in operations research.

Option VI for the student specializing in biomedical information processing.

Option VII for the student specializing in administrative science.

Each of these options provides a background in several aspects of computer and information science, as well as additional mathematical sophistication appropriate to the student's interest. Each of the options may lead to the Doctoral program in computer and information science, and each may be taken with a thesis option or without a thesis option. (See Appendix A for a listing of courses by number and title.)

All courses of study at the Master's level require completion of a core program in computer and information science, together with the required courses specified for one of the options and additional courses as specified by the student's adviser. The core program includes courses on; Principles of Man-Machine Interaction, Numerical Analysis, Data Structures, Advanced Computer Programming, Digital Computer Organization, Mathematical Foundations of Computer and Information Science, Introduction to Linguistic Analysis, Modern Methods of Information Storage and Retrieval, and Advanced Seminar in Computer and Information Science.

The graduate program leading to the Doctoral Degree in Computer and Information Science is flexible in that it is tailored to the particular background and interests of the individual student. These interests may lie in any one of the research and instructional areas already listed as well as in many

other cognate areas. A cognate field is defined as a field supporting or closely related to the fourteen Departmental fields and is ordinarily specified by an integrated program of study in other departments of the University.

Course Offerings

Currently there are about 81 courses (each one quarter in length) offered by the Department, 22 of which are largely undergraduate with the remainder being upper level undergraduate and graduate courses. In addition to these courses there are over two hundred courses offered by a variety of departments of the University which are of interest to our graduate students who are encouraged to take these courses.

Faculty

The Department of Computer and Information Science has a full time faculty of twenty-two members at the assistant professor level and above. They have a wide range of backgrounds and experience. The above faculty is supplemented by staff who have joint appointments with other departments; by staff from other departments who teach courses primarily for Computer and Information Science students; and by adjunct staff people who are employed in off campus organizations who teach courses in the Department of Computer and Information Science (see Appendix B). There are currently a total of about 12 supplemental staff in this category.

INTERACTION WITHIN THE UNIVERSITY

Both the Research Center and the Department of Computer and Information Science interact with other departments and research programs within the University. This is essential because of the multi-disciplinary nature of the activities encompassed in this field. A number of the academic faculty have joint appointments in other departments. Staff members of the Department of Computer and Information Science have appointments in the following departments and organizations:

a. Accounting
b. Allied Medicine
c. Art
d. Biophysics
e. Electrical Engineering
f. Engineering Graphics
g. Instruction and Research Computer Center
h. Mathematics
i. Psychology
j. University Libraries
k. University Systems Computer Center

INTERACTION WITHIN THE COMPUTER AND INFORMATION SCIENCE COMMUNITY

Columbus, Ohio is one of the major centers for information science and for the transfer of information in the United States. A number of organizations are involved with the activities of computer and information science. This affords an opportunity for students and faculty to interact with appropriate personnel in these organizations. Some of these are:

a. Chemical Abstracts Service
b. Battelle Memorial Institute
c. Bell Laboratories
d. City National Bank
e. Columbus and Southern Ohio Electric Company
f. Western Electric Corporation
g. Rockwell International Corp.
h. Industrial Nucleonics
i. State of Ohio Department of Finance; Department of Highways
j. Columbus Board of Education
k. Ohio College Library Center

There are a large number of scientists who come to Columbus in order to visit with the Department and who usually present a seminar. (The seminars for the period of this report are listed in Appendix C.) These persons cover virtually all phases of computer and information science.

In addition, our people interact at most of the major technical meetings in this country as participants giving papers, assisting on panels, as attendees, and as officials. Hardly a major technical meeting in the appropriate fields is held without a contribution from one or more of the personnel from the Ohio State Computer and Information Science Research Center. A list of these activities can be found in Appendix D.

Research efforts of the staff are disseminated to the professional community through several publication channels. A list of current publications of the Research Center staff is included as Appendix E. In addition, the Research Center issues a technical report series (see Appendix F).

DOCTOR OF PHILOSOPHY DEGREE

The Doctor of Philosophy degree was awarded to the following students during 1976-76. See Appendix G for a complete listing of Ph.D. dissertations.

Name	Dissertation
Richard I. Baum	The Architectural Design of a Secure Data Base Management System
Balakrishnan Dasarathy	Some Maximum Location and Pattern Separation Problems: Theory and Algorithms
Hillyard Rex Hartson	Languages for Specifying Protection Requirements in Data Base Systems - A Semantic Model
Otto C. Juelich	Compilation of Sequential Programs for Parallel Execution
Donald L. Kalmey	Comparative Studies Towards the Performance Evaluation of Software for Solving Systems of Nonlinear Equations
Gautam Kar	A Distance Measure for Automatic Sequential Document Classification System

Jack Michael Moshell	Parallel Recognition of Formal Languages by Cellular Automata
Sead Muftic	Design and Operations of a Secure Computer System
Arthur B. Pyster	Formal Translation of Phrase-Structured Languages
Cecil C. Reames	System Design of the Distributed Loop Computer Network
Phillip M. Russo	Cellular Networks and Algorithms for Parallel Processing of Non-numeric Data Encountered in Information Storage and Retrieval Applications
Viswanathan Santhanam	Prefix Encoding with Arbitrary Cost Code Symbols

II. INFORMATION STORAGE AND RETRIEVAL

ALGORITHMIC VOCABULARY CONTROL IN PRINTED INDEXES DERIVED FROM NATURAL LANGUAGE TEXT

Most indexes produced by automatic indexing techniques, such as KWIC and KWOC, are totally lacking in vocabulary control. As a consequence, information on a given topic may be scattered among many inflectional and derivational forms of a word (or phrase) as well as under synonyms having totally different word stems. In extreme cases, some inflected forms pertaining to one concept are completely separated from each other by words unrelated to that concept. This is illustrated by the alphabetically ordered keyword sequence cat, catabolism, catalysis, cataract, cathode, cation, cats where the words cat and cats are scattered from each other by unrelated keywords.

To eliminate or minimize such scattering problems, algorithmic methods of vocabulary control are being explored in this research as an alternative to the customary thesaurus or dictionary approach used in manually created indexes and in a few automatically produced indexes. Algorithmic methods offer distinct advantages for automatic indexing techniques, like KWIC and KWOC, which are applied in many ad hoc situations where thesauri are either unavailable or, if available, are too large to use in any practical way. The approach taken in this research involves development of stemming-recoding algorithms which not only recognize conceptually related keywords via removal of their inflectional and derivational endings, but create preferred index words by appending suitable suffixes to the word roots obtained from the stemming process. The preferred index words so created provide a fairly high degree of vocabulary control in the indexing system to which they are applied.

The stemming-recoding algorithms used for this purpose are being developed with the aid of forward and reverse lexicons prepared from a 10^6 token sample (7×10^4 word sample) derived from natural language titles of journal articles. The sampling of words and suffix endings in these lexicons appears to be somewhat better than those used in several previous suffix removal studies described in the literature. Consequently, the stemming algorithms developed in this study are expected to be somewhat superior to those reported previously. An objective and quantitative evaluation technique has been developed (see separate abstract) to determine whether or not the algorithms are indeed superior to those reported previously.

A. E. Petrarca, W. S. Stalcup

A METHODOLOGY FOR THE PERFORMANCE EVALUATION OF INFORMATION SYSTEMS UNDER MULTIPLE CRITERIA

An information system can be viewed as a symbiotic relation between the users of the system and the system's hardware, software and data resources. Ideally, performance evaluation of these systems should be based on the achievement of user based criteria while concurrently minimizing resource costs. Current evaluation technologies concentrate on only one aspect of the system, i.e., either the user or the resources. The ability to ascertain the impact of resource modification on user goals or vice versa is not readily achievable with these technologies.

This research develops a methodology that addresses this problem of multiple criteria evaluation of information systems. A set of evaluative procedures are formulated which provide the analyst/designer with the ability to relate resource usage and management to designer goal attainment, and which identifies designer options for either increasing the goal attainment level or reducing resource costs. The methodology is a general one in the sense of its applicability both with respect to the complexity of the hardware and software resources incorporated into the design and to the system's user environments and requirements.

T. G. DeLutis, J. S. Chandler (Sponsor: National Science Foundation. Grant SIS-75-21648)

DEVELOPMENT OF A UDC AUTOMATIC CLASSIFICATION SYSTEM

Under sponsorship of NSF Grant GN 36340 from the Office of Science Information Service, an automatic document classification technique was developed. This technique uses a sequential approach in analyzing the document to be classified, and utilizes a Bayes distance measure to indicate a correct class as well as to detect and eliminate noisy keywords. In the sequential approach, only a portion of the document is scanned before a decision is made. At that point the document is associated with those several classes which best describe the subject content of the document.

This technique has been modified for the automatic classification of abstracts using 110 classes derived from the Universal Decimal Code (UDC). These abstracts deal with widely diverse technical subject areas spanning the entire UDC classification schedule. A sample set of representative documents was first analyzed to which one or more UDC codes were assigned, and this study produced keywords and frequency distributions which characterize the 110 selected classes. Experiments with test documents using 3333 keywords have shown that in 64% of the documents the assigned UDC code could be matched. Manual indexing has indicated that 74% of the classes chosen were appropriate, and that for 87% of the test documents, at least one class chosen was a primary class for that document. These results are very encouraging for such a large scale application and diverse data base, and it is expected that the method will be implemented for this data base in a production environment.

L. J. White, A. E. Petrarca, L. Crawford, B. Brinkman, S. Mittal (Sponsor: Rome Air Development Center. Contract F30602-76-C-0102)

ON-LINE RETRIEVAL SYSTEMS FOR PERSONALIZED COMPUTER READABLE FILES DERIVED FROM CURRENT AWARENESS SEARCHING OF LARGE FILES

The only outputs which a user can obtain from most automated document retrieval systems currently in operation are printed bibliographic listings (and in some cases indexes thereof) which may be printed on standard computer paper, or on various types of cards to facilitate manual filing of the information. Ironically, if a user accumulates such outputs from current-awareness searches over an extended period of time, he begins to amass a personal file of bibliographic data which can only be stored (and hence searched) as a primitive manual file in which the individual items are retrievable on a single access point (e.g., first author's last name, an accession number, or journal reference data, etc.). He would have to go through a considerable amount of manual reprocessing to create index files which would allow him to retrieve the items on more than one access point, whether this were to be accomplished through the use of conventional subject heading cards, edgenotched cards, peek-a-boo cards, uniterm cards, or any variations thereof.

In view of the fact that these personal-file items are retrieved from larger files which are already in computer-readable format, we are experimenting with computerized retrieval systems whose inputs consist of personalized items retrieved through current-awareness searching of large centralized files. A prototype system was developed for a small research group interested in on-line bibliographic retrieval support for graduate research in chemistry. The prototype system was implemented on a NOVA 800 minicomputer manufactured by Data General Corporation. Further research is contemplated on improved methods of interfacing such personalized systems with the centralized systems from which they are derived, and on the use of such systems for certain types of performance evaluation and improvement of the centralized systems.

A. E. Petrarca, J. J. Henry, J. H. Hsu

AUTOMATIC PROFILE ENHANCEMENT BASED ON ASSOCIATION MEASURES DERIVED FROM SDI SEARCH PROFILES

For most SDI (Selective Dissemination of Information) systems, a considerable amount of intellectual effort is expended on preparation and revision of search profiles used for current-awareness and retrospective searching of large dynamic document collections. Consequently, association measures derived from SDI profiles are being explored as a means of utilizing this intellectual effort for automatic profile enhancement to improve the retrieval performance of such systems.

Initial tests based on a relatively small current awareness system with 227 profiles have produced encouraging results. Some potential problem areas involving the effects of term truncation and Boolean operations on profile-profile and term-term associations developed from the profile-term matrix are currently being dealt with prior to conducting broader tests on a much larger (2000 profile) current-awareness system.

A. E. Petrarca, B. J. Brinkman

EVALUATING THE EFFECTIVENESS OF VOCABULARY CONTROL ALGORITHMS USED IN AUTOMATIC INDEXING

The purpose of introducing automatic vocabulary control in printed keyword indexes derived from natural language text is to reduce the amount of concept scattering that would otherwise be found in such keyword indexes. In order to evaluate the effectiveness of some automatic vocabulary control techniques which are being studied (see separate abstract), an objective and quantitative method of performing such evaluations has been developed. The method is intuitively based on the difference in index entropy between any given index and its corresponding ideal index. An ideal index is defined as any index free of concept scattering; such an index comprises a set of index entries properly arranged under perfectly ordered headings such that each concept is represented by exactly one heading. The ordering of concepts and entries within an ideal index, which is achieved through perfect vocabulary control, is thus consistent with the notion of zero index entropy of the signals (index headings) relative to the messages (concepts) being transmitted by the index. Conversely, the disorder associated with the concept scattering found in a nonideal index (i.e., one without adequate vocabulary control) gives rise to some undesirable index entropy in the signals relative to the messages being transmitted because of the increased uncertainty of locating all information on a given topic in the index. This undesirable index intropy (concept scattering entropy) can be calculated for any nonideal index, relative to its corresponding ideal index, on the basis of the number of concepts in the index, the number of headings (index terms) associated with each concept, the number of entries under each heading, and the ordering of the headings relative to the ordering of the concepts they represent. The extent to which the concept scattering entropy of an index with no vocabulary control is reduced by a particular automatic vocabulary control technique can be used as a measure of the effectiveness of that technique.

A. E. Petrarca, W. S. Stalcup

III. COMPUTER FACILITIES

THE MICROCOMPUTER LABORATORY

The Microcomputer Laboratory currently is engaged in the design and implementation of a multiuser BASIC system to be run on a MOTOROLA EXORciser microcomputer. The microcomputer has been provided by the MOTOROLA Company on extended loan, and currently has 8K bytes of RAM, various I/O boards, and the ability to connect to various experiments.

The BASIC compiler is designed to support users in a multiprogramming environment. It will be a true compiler, generating directly executing code, rather than the interpreter-based implementations generally done. Extension facilities will be provided in the compiler to allow various additons to BASIC for such tasks as data acquisition, interactive graphics, assembler subroutine linkage, etc.

A. P. Lucido

THE COMPUTER EXPERIMENTATION FACILITY

The Computer Experimentation Facility provides its users with an interactive graphics device (the Applications Group, Inc., Model AG-60), a sonic pen, "touch panel", plotter, and other facilities. Being developed jointly with the Engineering Graphics Department and funded from the French Fellowship, a small but active group of workers have developed software to handle touch panel input, an advanced plotting package, some computer aided design work, 3-D object manipulation, and various graphics system software.

A. P. Lucido, C. Kearns (Sponsor: French Fellowship of the Engineering Graphics Department)

IV. INFORMATION ANALYSIS

THE DEVELOPMENT AND APPLICATION OF A THEORY OF INFORMATION FLOW AND ANALYSIS

A generalized framework for developing analytical and conceptual relationships involving the flow of information has been suggested. Our formulation depends on the definition that *information is data of value in decision-making.* As a consequence, a measure of the amount of information in a data set or message is defined in terms of a quantity called the *decision state of a decision-maker.*

A decision matrix together with a value matrix are used to completely define the entire decision situation. These two matrices explicitly relate courses of action to:

1. observable outcomes;
2. values of these outcomes to the decision-maker;
3. the states of nature.

These matrices may be defined to be the *decision state of the decision-maker.* We define the impact that information has on reducing the uncertainty of the decision state as our measure of information. The uncertainty which exists for any decision state is defined as a function of the mean square variance σ^2 of the expected value of the various courses of action. The information contained in a decision state is related to σ^2/μ^2 since information should be measured by relating it to the variance measured in units of the mean of the expected values of the various courses of action. This relationship becomes

$$I = \sigma^2/\mu^2 = m \sum_{i=1}^{m} \{REV(a_i)\}^2 - 1,$$

where $REV(a_i)$ is the relative expected value of course of action i. The information is defined in terms of a "binary choice unit" which represents the amount of information in a two-choice deterministic situation. This measure is universally applicable for all information that is concerned with the effectiveness of the data upon the recipient.

The amount of information in a data set or message can be measured by computing the difference in the amount of information in the decision state after and before receipt of the data. That is, the amount of information is arrived at by considering the impact this new data has on the decision-maker's decision state.

We have attempted to apply this model to data gathered in an information storage and retrieval experiment which was done earlier elsewhere. The amount of information in several classes of surrogates was measured in order to determine which class was the best predictor of document relevancy. For each query,

the subjects of the experiment were asked to predict, from a given surrogate, whether or not the corresponding document was relevant. Hence the *courses of action* were (1) predict relevant, (2) predict non-relevant; and the *possible outcomes* were (1) document relevant, (2) document non-relevant. A model for this experiment was developed in terms of expected values of all the possible events but in order to pursue this model further, it is first necessary to develop a scheme for the assignment of negative values for incorrect predictions. A method of assigning negative values for outcomes which do not lead to goal attainment is being developed.

In order to examine the validity and utility of our information measure, a general decision-making situation has been simulated. This simulation has enabled us to begin to study the relationship between information, learning, and the effectiveness of different decision-makers. A learning rule has been developed for the updating of the executional probabilities in the decision matrix after each trial. Decision-maker-effectiveness is a measure which describes how well a decision-maker understands the current decision situation. In other words, how correct are his perceptions of the different alternatives, outcomes, outcome values, and outcome probabilities? Further work is being done on this measure.

Once the relationship between decision-maker-effectiveness and the information content of a data set has been established, it will be possible to formulate *information profiles* for data sets. Such an information profile would indicate the average information content of a data set as a function of decision-maker-effectiveness for all of the decision-makers for whom this data set serves as a resource. If such a profile could be determined for every data set to be stored in an information system, then some number derived from this profile could serve as an index of the composite value of this data set. This method could be of major importance for the development of a sound procedure for the design of more effective information systems.

J. G. Abilock, M. C. Yovits, L. L. Rose (Sponsor: National Science Foundation. GN 31628)

V. LINGUISTIC ANALYSIS

A FORMAL THEORY OF THE SYNTAX, SEMANTICS AND TRANSLATION OF PHRASE-STRUCTURE LANGUAGES

A formal definition for a semantics for arbitrary phrase structure grammars, called a phrase structure semantics, has been developed. It is a model of the following semantic philosophy: (1) it is phrases which have meaning, and (2) the meaning of a phrase is a function of its syntactic structure and of the meanings of its constituents. A pair (G,S) where G is a phrase structure grammar and S is a phrase structure semantics, is called a phrase structure language description. A language is not just a set of sentences, but a set of sentences with meanings assigned to them. The language of a psld is the set of all pairs (w,m) such that w is a sentence of the grammar and m is a non-empty meaning assigned to w by the language definition. The sets of sentences of the languages of psld's are just the recursively enumerable sets.

For any psld with a type 0 grammar there is a psld with a regular grammar which defines the same language, and there is a psld with a context free grammar which defines the same language and assigns the same phrase structures to all sentences (minus the context sensitive structural information). Translation is defined on the languages of psld's, and it has been shown that the translation function on the languages of arbitrary psld's is effectively computable. We define a special kind of translation, called a phrase structure translation, which is a generalization of a syntax-directed translation, and prove that, for arbitrary pairs of phrase structure languages, a phrase structure translation exists between them iff any translation exists between them. Phrase structure translations are generally fast because they require no semantic computation at translation time. Several other decidability results about translations are also proven.

H. W. Buttelmann (Sponsor: Air Force Office of Scientific Research. Grant 75-2811)

COMPUTATIONAL COMPLEXITY OF SYNTAX DIRECTED TRANSLATIONS

The general result for table translators is that for ambiguous languages where <u>all</u> translations are required, translation time is bounded by

$$\Pi + (k_1^{k_2 n})((k_2 n)!)\phi,$$

where Π is parsing time, ϕ is the time to check syntactically valid sentences for semantic invalidity, n is input sentence length, and k_1 and k_2 are constants. For unambiguous languages, translation time is $\leq \Pi + \phi kn$, and if there is also no semantic deviance, $\leq \Pi + kn$.

R. Krishnaswamy, H. W. Buttelmann (Sponsor: Air Force Office of Scientific Research. Grant 75-2811)

SEMANTIC-SYNTAX-DIRECTED TRANSLATION

This research investigates the role formal semantics can play in language translation. We introduce a family of syntax-directed translators hybridized to use formal semantic information about a string to partially direct its translation. The main result shown is that several members of this family of "semantic-syntax-directed translators" define semantic-preserving translations between any two languages which (1) have a recursive set of sentences; and (2) have sentences whose meanings are finite in number and computable by a total recursive function. The semantic model assigns meanings to strings indirectly by assigning meanings to their parses. Semantic "filters" are placed at various points in the translator which either prevent meaningless strings or meaningless parses from being translated. Translators which filter parses are more powerful than those which merely filter strings, which in turn are more powerful than those which do not filter at all. The syntax-directed translator is normally driven by a mapping from trees of the source grammar to trees of the target grammar. In some semantic-syntax-directed translators this mapping is a function both of syntactic and semantic structure, rather than just syntactic structure as is traditional. This change leads to more powerful and more transparent translators, revealing a tradeoff between the complexity of syntax and semantics for translation.

A. B. Pyster, H. W. Buttelmann (Sponsor: Air Force Office of Scientific Research. Grant 75-2811)

METHODOLOGY AND GENERATION OF LANGUAGE TRANSLATORS

This research continues the study of translation of phrase structure languages. We analyze three models of translators of increasing complexity. For each model, sufficient conditions are developed by which it can be proven that the models induce a translation from the source language to the target language. The conditions provided form a minimal set to prove correctness of the translators. Relationships between the models are investigated, and it is shown that the models describe a hierarchy of translators. The capabilities and limitations of these translators are also investigated. It is shown that each model can induce any computable translation.

This research also investigates machine aided generation of syntax directed translators. A restricted class of syntax directed translators, translators with identical semantics, is introduced. We provide an algorithm which accepts as input source and target language definitions, and produces a syntax directed translator as output. It is shown that, under certain conditions, the translator obtained by this algorithm is "maximal" in that the translation induced by any syntax directed translator with identical semantics is a restriction of this one.

R. Krishnaswamy, H. W. Buttelmann (Sponsor: Air Force Office of Scientific Research. Grant 75-2811)

CONTEXT-DEPENDENT TREE AUTOMATA

This research presents a new family of tree automata -- the "context-dependent tree automata" (CDTA). The CDTA are a generalization of standard root-to-frontier tree automata studied by Rabin and Rounds. Standard tree automata are limited by the "localness" of the state transition map. Using standard automata, it is impossible to coordinate the processing of two or more distinct loci of the input tree. Thus, it is known that standard tree automata recognize only trees whose frontiers are context-free languages. The CDTA permit limited "communication" between different loci of the input tree in much the same fashion as the heads on a multi-tape finite-state automaton may be coordinated. Consequently, the deterministic CDTA recognize the derivation trees generated by arbitrary context-dependent grammars, and trees whose frontiers are arbitrary recursively enumerable sets. However, there are recursive sets of trees which non-deterministic CDTA cannot recognize. The non-deterministic CDTA is more powerful than the deterministic CDTA. Furthermore, the closure properties of the CDTA under Boolean operations is investigated. The CDTA recognize "highly transparent" derivations of many context-dependent languages. These derivations are simpler than those generated by context-dependent grammars. Thus it is hoped that the CDTA will provide a useful alternative to Chomsky's context-dependent generative grammars.

A. B. Pyster

STUDIES IN GENERATION OF PHRASE STRUCTURE TRANSLATORS

Phrase structure translators are defined in earler research also abstracted in this publication. This research is studying algorithms for generating general phrase structure translators, given two arbitrary phrase structure language definitions. Questions of effectiveness and complexity of the problem are being investigated. Running computer programs of translators and translator generators have been developed and are used to develop and study the algorithms.

H. W. Buttelmann (Sponsor: Air Force Office of Scientific Research. Grant 75-2811)

STRUCTURE OF COMPUTER AND NATURAL LANGUAGE ALGORITHMS

Recent investigations into the physical structure of computer algorithms have revealed apparent similarities to the way natural language text is written. These similarities involve such things as the distribution of occurrences of, and relationship that exist amongst the various intities of which algorithms (natural language texts) are composed.

One of the chief problems encountered in such a study is the ability to classify entities for computer and natural languages in a like manner. Such a classification scheme has been proposed and is currently being tested using a computer assisted language analysis system. In addition, applications of the research to information storage and retrieval and to language complexity measures are being investigated.

S. H. Zweben, A. L. Baker

SEMANTIC PROCESSING STUDIES FOR NATURAL-LANGUAGE UNDERSTANDING SYSTEMS

We are investigating methods of performing semantic interpretation in natural-language understanding systems. The question under investigation is whether syntactic and semantic processing can be merged. We previously developed a semantic processor, SPS, that depended on syntactic preprocessing. In working on this system, we noted numerous similarities between semantic and syntactic processing. Two alternative attempts at merger are being pursued. First, SPS is being further developed in order to clarify exactly what syntactic processing is necessary for its operation. Secondly, the Augmented Transition Network (ATN) model for syntactic processing is being extended to incorporate as many semantic processing features as possible.

N. K. Sondheimer, S. Kwasny, D. Perry

SPATIAL REFERENCE AND NATURAL-LANGUAGE MACHINE CONTROL

Current research on natural-language speech-understanding provides encouragement for the development of systems for the vocal control of mechanical devices. However, the designer of such systems faces a variety of difficulties in allowing for references to the position, orientation, and direction of objects and actions in space. The aim of this research is to analyze the sources of these difficulties and conceivable solutions to them. The effects of physical environment on the interpretation of such references, sometimes called space-deixis, is being considered. Possible restrictions on linguistic form and meaning are being developed. Also being developed is a logic of spatial reference.

N. K. Sondheimer

DEVELOPMENT OF A METHODOLOGY FOR NATURAL-LANGUAGE MACHINE-CONTROL ELICITATION EXPERIMENTS

The objective of this work is the development of materials and procedures to assist in the determination of the commands that humans prefer to use in the real-time control of machines. These findings will be used in the design of experimental studies of natural-language machine control. These experiments are necessary in order to develop fully such control. Current natural language-understanding computer systems are only capable of understanding carefully selected subsets of English. Useful natural-language machine control must allow for the language forms speakers prefer.

There are many uses for limited machine-control systems. Applications arise in Computer-Aided Manufacturing, including primary or supplementary control of numerically controlled machine tools, warehousing systems, or industrial manipulators (mechanical arms). Applications also arise with teleoperators, like unmanned vehicles or laboratories for manipulating dangerous substances. Finally, and perhaps most importantly, natural-language machine control ought to be used to give the quadraplegic control over his environment.

N. K. Sondheimer

VI. ARTIFICIAL INTELLIGENCE

COMPARATIVE EVALUATION OF STORED-PATTERN CLASSIFIERS FOR RADAR AIRCRAFT IDENTIFICATION

Design and evaluation of classification algorithms for a pattern recognition problem are investigated. The problem is one that is encountered in the design of a radar aircraft identification system. This problem differs from the usual paradigm encountered in statistical pattern recognition theory. Here classes are characterized by labeled training patterns that are considered to be ideal. The test pattern is a noisy version of one of the ideal patterns, where noise is generated by a statistical process.

The situation where the noise perturbation is Gaussian is considered in detail. The Bayes classifier in this case has the form of the Sebestyen classifier. Techniques for efficient computer implementation, and evaluation of the Sebestyen classifier are developed. A relationship between the Sebestyen classifier and a nearest-neighbor classifier that utilizes the ideal patterns as its reference set is obtained. When reference patterns satisfy certain location constraints, it is shown that the decision surfaces of the two classifiers are identical.

Classifier performance is evaluated in terms of misclassification probability, "classification bias", computational economy, and the effect of changes in classifier parameters. These parameters include dimensionality, assumed value of the noise level, and the number of subclasses in each class.

The problem of classifier design when more than one noisy pattern can be used to make a decision is also considered. This is the problem of efficient utilization of cumulative evidence to improve classifier performance. One of the procedures evaluated operates by taking a majority-vote over multiple decisions of a given classifier. It is shown that the misclassification probability of a majority-vote procedure increases monotonically with the "classification bias" of the given classifier. Finally, the performance of such a procedure is compared to that of a method which utilizes the Sebestyen classifier in a sequential mode.

S. N. Srihari, L. J. White (Sponsor: Air Force Office of Scientific Research. Grant 69-1710)

GRAMMATICAL INFERENCE PROBLEM

The problem of grammatical inference for regular grammars can be solved algorithmically and has application in syntactic methods for pattern recognition and in programming language design. Given a set of strings, S, from the target language L, the algorithm first constructs a minimal grammar M_0 to generate exactly S. In searching for a grammar for L, the algorithm effectively prunes a lattice consisting of all grammars produced by merging nonterminals of M_0. Two such grammars from the lattice are considered in order to find a string x which is generated by exactly one of the two. The lattice is partitioned into two parts, those grammars which generate x and those which do not. Using an oracle, or teacher, to determine whether $x \in L$, the algorithm then eliminates the one part of the binary partition containing grammars which can no longer be considered as candidates for L. This process at each step does maximal pruning of the lattice using the information from the oracle.

The solution is being extended to inference of context-free grammars. This problem, however, cannot be solved algorithmically, but rather a solution is produced in the limit due to the unsolvability of the equivalence problem for context-free grammars.

L. J. White, D. A. Marik (Sponsor: Air Force Office of Scientific Research. Grant 72-2351)

GENERALIZED ORTHOGONAL REGRESSION IN PATTERN RECOGNITION

Conventional curve fitting usually uses least squares regression in which one variable is taken as errorless, the other having some error distribution, e.g. Gaussian. For straight lines "y on x" regression is the most common. If a straight line is the "pattern" to be "recognized" from sample data points, however, both coordinates depend on the observer's choice of viewpoint and one has no greater claim to special treatment than the other. The proper "recognition regression" should be invariant under transformation of coordinates. In addition, the concept of error is vacuous along the straight line. Orthogonal regression is appropriate (choose the line minimizing sum of squares of deviations of data points in direction perpendicular to the line) as it has both the invariance property needed and ascribes error to the direction along which it is meaningful. These considerations appear to generalize naturally to recognition of geometrical patterns (in appropriate parameter or feature spaces) whose generation can be described by the action, on a running "point", of a transformation group or semigroup. The error, in a least squares sense, is computed for coordinates orthogonal to those corresponding to the trajectories of the running point. The number of the dimensions of the pattern description space is the sum of the number of dimensions (parameters) of the pattern generating group or semigroup and the number of dimensions (variates) along which meaningful regression occurs.

J. Rothstein

STRAIGHT LINE STATISTICAL PATTERN RECOGNITION WITH CELLULAR AUTOMATA

This research is related to straight line recognition algorithms for cellular automata earlier developed by Rothstein and Weiman, and to the work on bus automata for formal language recognition by Rothstein and Moshell. Its goal is to use bus automata, computing in highly parallel fashion, to fit a statistically optimal straight line to given data points. Many subsidiary problems arose, one, the proper kind of regression to do, being treated in the proceeding abstract. The others stem from various aspects of making statistical computations with cellular automata, and because this is a pioneering effort, they are novel, diverse, and numerous. Work is in progress on how to encode and organize data which describes distributed discretized geometrical properties and to process it by cooperative arrays of automata which communicate over busses constructed by the automata themselves. The complex interplay between problem facets ordinarily classified as hardware, storage and retrieval, data descriptive languages, programming languages, and system programming is central to this research.

J. Rothstein, J. Mellby

NATURAL LANGUAGE INPUT FOR COMPUTER GRAPHICS SYSTEMS

This research focuses on the feasibility of constructing a practical graphics system for use by untrained users. A pilot system is being designed and built to investigate graphical, linguistic, and organizational issues.

We believe that successful interaction with a system is dependent on the "naturalness" of the modes of communication, both to and from the system. The first phase of our system will allow Natural Language input and Graphical output. This will be extended to include I/O in both modes. Such interaction is feasible only if the system has a large amount of knowledge, both about language and pictures, and about the relationship between them. Our investigations center around designing an appropriate subset of English, constructing an analyzer for that subset, determining the knowledge which is required by the system, and structuring that knowledge in a way compatible with its linguistic and graphic components.

It is not the major purpose of this research to develop totally new methods in Artificial Intelligence, Natural Language Processing, or Computer Graphics, but instead to integrate previously unmarried techniques in those areas. However, several unsolved problems have already been uncovered which has added impetus to the research.

D. C. Brown, H. W. Buttelmann, B. Chandrasekaran, S. C. Kwasny, A. P. Lucido, N. K. Sondheimer

FINITE MEMORY DECISION THEORY

In this research we continue our investigation of the effect of finite memory constraints on some problems in decision theory. During the period under report, we have explored the design of optimal finite memory automata for the following problems: multiple hypothesis testing, compound hypothesis testing, and the one- and two-armed bandit problems.

A lower bound has been obtained for P(e), the probability of error, for an m-state automaton used to choose one of K hypotheses. This bound is, in general, not tight. However, for the symmetric hypothesis testing problem, an automaton can be designed whose probability of error is arbitrarily close to this bound, with an additional memory requirement of only b bits, where b is a function of K, the number of hypotheses, and not of the problem parameters or of m.

The compound hypothesis testing problem for the case of Bernoulli variables, i.e., the case where the hypotheses are of the form, $p \geq p_0$ vs. $p \leq p_1$ ($p_0 \geq p_1$) was investigated. A greatest lower bound for P(e), under the minimax principle, was derived and an ε-optimal class of automata has been demonstrated.

ε-optimal randomized automata have been found for the one- and two-armed bandit problems also. It has also been shown that an addition of 3 bits of memory can replace the need for the artificial randomization, still maintaining the same performance.

B. Chandrasekaran, K. B. Lakshmanan (Sponsor: Air Force Office of Scientific Research. Grant 72-2351)

THE INTEGRATION OF GRAPHICAL AND SEMANTIC KNOWLEDGE

This work addresses the problem of integrating graphical and semantic knowledge into a data-base for the support of Graphics and Natural Language Processing systems. The goal of the project is to allow graphical information to be used in the interpretation of linguistic forms and semantic information to be used in the interpretation and construction of graphical structures. Achieving this goal should facilitate man-machine interaction.

As part of the project, current programs and structures in the areas of Computational Semantics, and Computer Graphics, are being considered with the intention of isolating suitable structures and techniques or identifying the need for new ones. Some sample dialogues between a user and a hypothetical Graphics system are being analyzed in order to determine the nature of the techniques required. This analysis has led to a better understanding of the degree of interaction between forms of knowledge, and of the possible organization of the data-base. Suitable domains for use in development of a prototype system are also being considered.

D. C. Brown, B. Chandrasekaran, A. P. Lucido, N. K. Sondheimer

VII. INFORMATION PROCESSES IN PHYSICAL, BIOLOGICAL AND SOCIAL SYSTEMS

THE DESIGN AND IMPLEMENTATION OF A COMPUTERIZED CANCER PATIENT INFORMATION AND DATA CONTROL SYSTEM

The objectives of this research are to design and implement in cooperation with the Ohio State University Comprehensive Cancer Research Center an integrated cancer patient information and data control system. The implemented system will integrate all existing and contemplated OSU cancer data bases into a unified computerized information system which will be responsible for data collection, quality control, storage and retrieval, data exchange, dissemination, and statistical and epidemiological processing services. The developed system will be compatible with the emerging National Cancer Institute's Comprehensive Cancer Patient Data System currently under development. The system is designed for use by epidemiologists, biostatisticians, clinicians and public health personnel in studies relating to the surveilance, detection, cure, treatment and prevention of cancer.

K. C. O'Kane, B. K. Pflug

THE DESIGN AND IMPLEMENTATION OF A COMPUTERIZED MEDICAL DIAGNOSTIC SYSTEM APPLIED TO OBSTETRICS AND GYNECOLOGY

Diagnosis is the endpoint of a logical process which involves the formulation of various hypotheses based upon the signs and symptoms with which the patient presents. Once the basic hypotheses are formulated, a deductive process ensues which leads, logically, to the most probable hypothesis which is called the diagnosis. In this research, various statistical diagnostic techniques are examined as they apply to a standard machine coded corpus of obstetrics data covering several thousand patients. The goal of this research is to identify and implement a computerized system which can determine from a limited set of inexpensively gathered data which patients from the population belong to certain high risk groups. The significance of such a system is that it would enable high risk candidates to be isolated from the general population for special attention thereby increasing the quality of health care delivery and reducing overall costs.

K. C. O'Kane, E. E. McColligan

VIII. MATHEMATICAL TECHNIQUES

SIMULATION MODELS FOR NEO-MALTHUSIAN POPULATION DYNAMICS

In several studies of actual and modeled subsistence systems it has been found that the environmental carrying capacity is never exceeded nor is it even reached. This is in contrast to the overpopulation predicted by Malthusian models. This research aims to isolate those factors which determine whether such behavior occurs. Both simulation and analytical models will be used.

Several factors will be included in the models, including demographic and settlement patterns, changing carrying capacity as influenced by climate and other factors, kinship patterns and subsistence mechanisms. An important task is to distinguish those factors that are influential from those that are not. One of the most telling criticisms of computer simulation models is that they do not deal with populations of a realistic size. Of course the reason is that the large number of interactions between, say, 50 individuals and their offspring is costly to simulate already. A call for simulation of populations of 500 individuals is troublesome. An important aim of this research is to find ways of handling larger populations within the reasonable time bounds.

D. J. Moore

BINARY STRINGS AND TOPOLOGY

Another path into unknown territory has been uncovered. It corresponds to the problem of translation between formal languages linked by a common semantics, the latter provided by the underlying topological meanings to which the strings in the languages correspond. Specifically, in a measurable metric space, binary strings {0,1} can be put in biunique correspondence with a basis of neighborhoods for any bounded, compact, connected subset of the space. Each successive "bisection" must reduce both diameter and measure of the parts so that both approach zero. Points correspond to infinite strings, and with no loss in generality, can be identified with infinite binary decimals exactly as in the definition of real numbers. As there are an infinite number of "bisection policies", each of which gives different geometric or topological meanings to the strings over {0,1}, each policy defines a language whose "words" and "sentences" are "translations" of the words or sentences in other languages which refer to the common geometrical "meaning" involved.

It looks as if the problem of computing translations in this case not only is very general, but also contains the problems of approximation and discrete representations of continua as well.

J. Rothstein

SELF-SOLVING QUASIGROUPS

This investigation, continued from last year, has produced many new theorems. Recall that groupoids satisfying the condition, ab = c implies a = bc, are quasigroups, which we call self-solving quasigroups. We now list some new results. A finite self-solving quasigroup whose elements are unipotent is necessarily of even order; if its elements are all idempotent its order is necessarily odd; there is a natural biunique correspondence between them when their orders are respectively $2m$ and $2m - 1$, $m = 1,2, \ldots$. For the commutative case there is a further biunique correspondence between these cases and the Steiner triple systems (or the block designs associated with the latter). Self-solving quasigroups of infinite order exist for an endless hierarchy of transfinite cardinal numbers (countable, continuous, and "exponentiated" higher orders of infinity). Computations involving these quasigroups are frequently amenable to parallel processing. Some initial considerations on applying these systems to cryptography and data security suggest that codes of arbitrarily high complexity for an "enemy" but of fixed complexity for a user can be devised, and there are so many such codes that one need never be used twice.

J. Rothstein

NUMBER TREES, SEMIGROUPS, AND FORMAL LANGUAGES

An abstract, with the above title, appears in the 1973-1974 Abstracts of Research. The work reported here concerns the ϕ-tree specifically (nodes labeled by the positive integers with directed edges from n to $\phi(n)$, where ϕ is the Euler function). It was previously shown that (1) all odd integers greater than one are "leaves" (i.e. for no integer k is $\phi(k)$ in that set of integers), (2) an odd prime p and $2p$ are "co-phi" ($\phi(p) = \phi(2p)$), with $2p$ a leaf iff $(2p + 1)$ is not prime. Many new theorems have been discovered, among them the following. The number of integers co-phi to an arbitrary integer N is finite, say $m(N)$, co-phi-ness is an equivalence relation on the integers, and if N_1 and N_2 are mutually prime then $m(N_1N_2) = m(N_1)m(N_2)$. This resembles, though it differs greatly from, the classical formula $\phi(N_1N_2) = \phi(N_1)\phi(N_2)$. There is no finite upper bound to $m(N)$ as N ranges over the integers. The fact that when p and $(2p + 1)$ are both prime, $2p$ is not a leaf, led to asking how long a "prime chain", $p_1, p_2, \ldots$, where the p_i are prime and $p_{i+1} = 2p_i + 1$, might be. It was shown that the length of the chain can never exceed p_1, p_1 an odd prime. This establishes the theorem that the ϕ-tree has an infinite number of even leaves. A significant generalization of the "main-stem slide" property of 2^n was discovered. As $\phi(2^n) = 2^{n-1}$, iterating the ϕ-function makes one "slide" down the powers of 2 to the root of the ϕ-tree. The generalization is that for any integer N there is a characteristic exponent e_N, integer m, and a set of primes and powers, $P_{N1}{}^{\alpha N1}$, $P_{N2}{}^{\alpha N1}, \ldots$ such that for $n >> e_N$, k and $k > m$

$$\phi^k(N^n) = (\Pi P_{Ni}{}^{\alpha i})\, N^{m-k}.$$

Also there is a characteristic level, 2^r, $r = r(n)$, for $k > n$, at which $\phi^k(N^n) = 2^r$.

J. Rothstein

OCTIC GROUP AND DUALITY BETWEEN MULTIPLICATION AND RELATIVISTIC VELOCITY ADDITION

This research began with the well-known group isomorphisms of addition of real numbers (+), multiplication of positive real numbers (P), and one-dimensional addition of sub-luminal velocities in special theory of relativity (S), normalized by choosing units making the velocity of light equal to unity. The identity elements in (+, P, S) are respectively (0, 1, 0), annihilators (zeros) are (∞, 0, 1), and if mappings N and R are defined by $Nx = -x$, $Rx = 1/x$, the respective inverse mappings are (N, R, N). Automorphic mappings between + and P (exponential and logarithmic functions) and between + and S (tanh and arctanh) are familiar, but that between P and S is its own inverse (here denoted by T; $Tx = (1-x)/(1+x)$). The transformations N, R, T generate a transformation group isomorphic to the group of symmetries of the square, called the octic group or dihedral group D_4 (order 8, non-commutative) with $R^2 = N^2 = T^2 = (RN)^2 = (NTN)^2 = I = (TN)^4 = (TR)^4$, $(TN)^2 = (TR)^2 = RN = NR$. We established relations formally analogous to duality and de Morgan's theorems in logic, where T is the analogue of negation, multiplication of reals (P) is the analogue of conjunction, and one dimensional relativistic velocity addition of disjunction. With $P(ab) = ab$, $S(ab) = (a+b)/(1+ab)$ we find $S(ab) = T(P(Ta, Tb))$. Symbolically, $S = TPT$: similarly $P = TST$. There is true duality stronger than the group isomorphism of P and S. R and N are dual: Ra is the group inverse of a in P, Na is the group inverse of a in S, they distribute over P and S operations respectively, $R = TNT$, $N = TRT$. Also N applied to a P product is equivalent to applying N to any one factor, while R applied to an S sum affects it as if it were applied to any one summand: $R(S(a,b)) = S(Ra,b) = S(a,Rb)$. T is self-dual. The identity in S is 0, which annihilates in P, 1 is the identity in P and annihilates in S, T maps 0 and 1 into each other.

A paper with the above title was presented at the Washington meeting of the American Physical Society, April 26-29, 1976. The manuscript, in preparation, is intended for submission to an appropriate journal.

J. Rothstein

VIERER GROUP DUAL OF ADDITION

Discovery of the octic group duality (preceding abstract) inspired a heuristic search for further dualities mediated by groups; ordinary duality corresponds to the cyclic group of order two generated by a single involutory operation (negation in the case of Boolean algebra). The involutory operation $R(Rx = 1/x)$ transforms addition (+) into a dual group operation (*) given by

$$a * b = R(Ra + Rb) = ab/(a + b).$$

Identities of (+, *) are $(0, \infty)$, annihilators are (∞, 0), the inverses of b are (-b, -b), i.e. both are Nb, and

$$a + b = R(Ra * Rb).$$

The group generated by R and N is the well-known vierer group (the only group of order 4 other than the cyclic group).

The dual group has more than passing interest, for writing

$$a * b = c$$

in terms of + gives

$$1/a + 1/b = 1/c.$$

This is precisely the parallel resistance (or impedance) formula of electrical circuit theory, with the duality above mirroring the well-known series-parallel circuit duality. Also, if c is fixed and called "focal length" then a and b are object and image distances from a lens or mirror of focal length c.

J. Rothstein

DUAL OF MULTIPLICATION VIA A GROUP ISOMORPHIC TO THE PERMUTATION GROUP ON THREE OBJECTS

As in the preceding two abstracts we use an involutory operation, here C, defined by $Cx = 1-x$, to construct a group dual to multiplication. We have

$$a * b = C(Ca \cdot Cb) = 1-(1-a)(1-b) = a + b - ab.$$

The identities for $(\cdot, *)$ are (1, 0), the annihilators are (0, 1), and the inverses of b are (Rb, CRCb). The transformation group generated by R and C is of order 6, non-commutative, and isomorphic to the group of permutations (symmetric group) on three objects S_3 (the only group of order 6 other than the cyclic group).

The dual group is of more than passing interest. Interpret b as the number or the fraction of the elements in some universe possessing attribute b, a * b as the number or fraction of elements possessing at least one of attributes a or b, ab as number or fraction possessing both attributes. Then the composition * expresses the famous principle of inclusion and exclusion in combinatorics, the basic rule for calculating the probability of a set (random event) in terms of probabilities of subsets constituting a covering of that set (overlap permitted), and suggests that a useful algebra of attributes in which group theory plays an important role awaits development.

J. Rothstein

DUALITY IN ALGEBRAIC STRUCTURES UNDER A TRANSFORMATION GROUP (DUALITY GROUP)

The three preceding abstracts extended the conventional duality concept (where an involutory biunique mapping on the underlying set A, which was a group, semigroup or algebra, engendered an isomorphic structure) to an extended duality involving a transformation group rather than a single transformation. Groups of order 2, 4, 6 and 8 were encountered, the last two being non-commutative. We seek to characterize these "duality groups" more closely. We noted the following theorems. (1) The duality group is a subgroup of the group of automorphisms

of the underlying structure. (2) If finite, the duality group must be of even order (the involutory mapping, say T, is of order 2 which must be a divisor of the order of the group). (3) If the underlying structure has nullary operations, i.e. special elements like identities or annihilators, say $\{e_i\}$, then the action of the duality group D on $\{e_i\}$ is a permutation of the set $\{e_i\}$ (this follows from $Te_i = e_j \rightarrow e_j = Te_i$). (4) All elements of D are unary invertible mappings on elements of A, among which are found those characteristic of structure A (for example, if inverse elements are defined in A for a binary operation, then $a \rightarrow a^{-1}$ defines a mapping, say R, and $R \in D$). (5) If B_1 and B_2 are dual binary operations, and R_1 and R_2 are corresponding dual unary operations, then $TR_1 = R_2T$, i.e. $R_2 = TR_1T$, $R_1 = TR_2T$, and for all a, b ϵ A we have

$$aB_2b = T(TaB_1Tb), \quad aB_1b = T(TaB_2Tb)$$

which are generalized de Morgan laws for dual binary operations. Similarly for dual n-ary ($n \rightarrow 1$) operations O^n we have

$$O_2^n(a, \ldots a_n) = TO_1^n(Ta, \ldots Ta_n)$$
$$O_1^n(a, \ldots a_n) = TO_2^n(Ta, \ldots Ta_n).$$

(6) In the multiplication table of D the elements which commute with T form a subgroup of D, are self-dual, and are symmetrically placed about the main diagonal. Those which do not comprise pairs symmetrically placed about the main diagonal such that if one is D_k, say, the other is TD_kT. (7) There seems to be no reason why D could not have infinite order. (8) The structure of A could be more general than the algebraic structures heretofore considered (e.g. lattices admit a dual order relation).

J. Rothstein

IX. SYSTEMS PROGRAMMING

COMPUTER OPERATING SYSTEM FACILITIES FOR THE AUTOMATIC CONTROL AND ACTIVITY SCHEDULING OF COMPUTER-BASED MANAGEMENT SYSTEMS

Well defined, efficient, and auditable activity and resource management is a key element in the success of computer-based management systems. In non-dedicated computing environments, the role of activity and resource management is currently embodied in the interface of human computer operators and job dispatchers with the computing facility's "operating system" software. The computer operating system is primarily capable of controlling and scheduling quanta of processing activities, most commonly referred to as "jobs" or "tasks." The timely resolution of logical inter-job dependencies and submittal of jobs to the computer operating system for physical scheduling and execution are generally roles assumed by the above-mentioned operational-clerical personnel. The primary goal of this research is to extend our concepts of computer operating systems into the realm of automatic control and activity scheduling of computer-based management systems.

Ultimately, this research will lead to computer operating constructs and a model, machine independent command language that would enable computer operating system interface at the level of a user applications system, as well as at the prevalant "job-task-operator" level.

Drawing upon existing technologies of administrative science and computer science, this research contributes significantly to the specific areas of management of computing resources, computer operating systems programming, systems analysis, and man-machine interface.

D. Isaacs, S. Mamrak, J. Kinard

ON THE EFFORT INVOLVED IN WRITING ALGORITHMS

It has been conjectured that it is possible to accurately estimate programming time through a posteriori measurements made on a debugged program. Recent experiments have tended to support this conjecture. New experiments are being done to test the effect of such factors as the individual programmer and his level of sophistication on these estimates. It is hoped that these experiments will eventually provide useful tools through which the productivity of programmers can be measured. In addition, since the concept of effort is intuitively related to the concept of complexity, this research may provide new insights toward answering complexity related questions regarding what makes a program difficult to write or, for that matter, understand.

S. H. Zweben

AN ON-LINE INTERACTIVE DATA BASE MANAGEMENT SYSTEM

Information Management Programming System (IMPS-II) is being developed as a prototype personalized on-line interactive data base management system. IMPS-II consists of two language components: (1) a Data Description Language (DDL) and (2) a Data Manipulation Language (DML). The DDL provides the user with the capability to describe the structure and contents of a data base, while the DML provides data base storage, retrieval, and maintenance capabilities. Single DML statements may be entered for immediate execution, or a "program", consisting of a sequence of DML statements, may be created and saved for execution at some subsequent time. A journal facility can be used to backup all or selected portions of an interactive session or to input, in a batch mode, a stream of commands from an external file. IMPS-II is written in ANS FORTRAN, providing maximum portability among different computer systems. Versions of IMPS-II are currently running on XEROX SIGMA-7 and IBM 370/165 computer systems. IMPS-II will be used to investigate the usefulness of differerent features of a personalized data base management system.

T. G. DeLutis, J. S. Chandler

THE COST-EFFECTIVENESS OF FILE CRYPTOGRAPHY

The cost-effectiveness of cryptographic transformations applied to files was investigated. Their effectiveness is measured by a security measure for cryptographic security which was developed. This measure, "the work factor of a statistic", differs from Shannon's classical measure of "unicity distance" and is specially suitable to file cryptography. The cost of file cryptography is measured in the CPU time overhead involved in enciphering and retrieval operations. Both cost and security were measured in a controlled experiment actually enciphering files. Different ciphers were tried and their relative cost and security discussed. Much valuable experience in file enciphering was also gained from the experiment.

E. Gudes, J. Rothstein, S. Zweben, H. Koch

REPRESENTATIVE WORKLOADS: A CASE FOR THE USE OF SELECTED PATTERN RECOGNITION TECHNIQUES

A representative drive workload is required for various computer system performance evaluation activities. Statistical pattern recognition provides a surprisingly appropriate framework and tools for developing such a workload. In particular, feature extraction and selection techniques are useful for finding the best set of performance variables which characterize system resource demands and clustering analysis techniques are appropriate for dividing jobs into subsets or classes in a manner that generates metrics for quantitatively describing the outcome of the comparison of real workload and drive workload properties. A workload generation methodology based on these pattern recognition techniques is proposed and an experimental application of the methodology is under investigation.

S. A. Mamrak, P. D. Amer

A NETWORK ACCESS MODULE TO AUGMENT USER COST-BENEFIT ANALYSIS

A cost-benefit analysis has been undertaken with the aim of assisting users in the dynamic environment of a computer network. A straight-forward function has been developed which is capable of locating an optimal time sharing system among many, from a cost-benefit point of view. An investigation is currently in progress to find a feasible format for implementing the cost-benefit analysis module on a network interface machine which provides network access services to users. In particular, implementation is planned for the NAM (Network Access Machine) developed at the National Bureau of Standards. The NAM is a dedicated minicomputer which presently provides such services as host system selection and logic, and service or resource selection and initialization.

S. A. Mamrak

INFORMATION SYSTEM DESIGN FOR REAL-TIME MULTIPROCESSING SYSTEMS

Most research about multiprocessing has concentrated on synchronization methods through special language statements and/or operating system capabilities. In contrast, our research is concerned with identifying and developing system design principles for information systems in a real-time multiprocessing environment. We do not assume that the processes of the system are independent. We have identified how interference can occur and show what is necessary to prevent it. Methods have been developed to determine which processes cannot be multiprocessed. We have shown that even some disjoint processes may not be multiprocessed. We have identified some system design principles that will yield a better system with respect to total throughput time and multiprocessor utilization. Our results do not depend upon any specific synchronization method.

H. S. Koch

DATABASE SYSTEM CONVERSION

This project investigates the support of higher level data models such as the relational model and DBTG model using an existing lower level database system. This includes the design of rules and procedures for transforming a data structure class to another data structure class such that the semantics of data are preserved. Next, the operations on one data structure class are to be simulated by operations on the other data structure class to achieve the preservation of operations. The transformation of data structure class and their operations will demonstrate a methodology for implementing a multi-level database system in achieving the goal of data independence. The lower level database system is supported by an unconventional computer hardware architecture using content-addressable memory concepts. This investigation will hopefully bring light to an efficient implementation of the relational and DBTG data models using the new database architecture.

F. K. Ng, D. K. Hsiao (Sponsor: Office of Naval Research. Grant N00014-75-C-0573)

CONTEXT PROTECTION IN DATA BASE SYSTEMS

The goal of this research is the development of a new type of protection mechanism known as the context protection mechanism for interactive data secure system.

In all currently known protection mechanisms access control decisions are made a priori on the basis of access rules related to users, data and data base operations. In this research an attempt is made to include protection mechanisms in which access control decisions depend upon additional factors such as past access history and the content of data units.

The results show that a protection mechanism, which uses past access history information in its access decisions, can enforce specific patterns of data base operations on one hand and can provide derivation protection on the other hand. This means that context protection can be applied not only to protect logical data elements in the data base, but also to provide information protection.

The protection mechanism is also implemented for verification and demonstration purposes.

D. Cohen, D. K. Hsiao, M. T. Liu (Sponsor: Office of Naval Research. Grant N00014-75-C-0573)

THE SELECTION OF EFFECTIVE COMPUTER PROGRAM TEST DATA BASED ON PROGRAM STRUCTURE ANALYSIS

Recently much attention has been focused on the inadequate reliability of computer software. The most promising avenue of research to improve software reliability is the systematic analysis of the traditional ad hoc method of program testing. This research develops a scientific basis for the testing process, investigates its capabilities, and identifies its limitations. An algorithm for the selection of near optimal test data is developed based on an analysis of the program code structure.

The underlying mechanism on which all program testing is based is "inferred correctness". That is, if a program is correct for a set of well-chosen test cases, then, with a certain degree of confidence, the program is inferred to be correct over all possible values of its input variables. A measure of the similarity between paths determines the strength of this inference. In the initial phase of processing this measure is also used to eliminate highly redundant paths from further consideration. A complexity measure is calculated to determine the initial worth of each of the remaining paths. At each point the test data selection algorithm will use these measures to choose the path that will test, both directly and by inference, the maximum untested code complexity.

E. I. Cohen, L. J. White

AN ON-LINE SYNTACTIC AID FOR HIGHLY PARAMETERIZED COMPUTER LANGUAGES

A recent trend in computer languages has been toward the development of specialized languages with highly parameterized and sometimes complex syntactic structures. A syntactic aid has been developed to assist the user who does not use the language frequently enough to develop or retain an in-depth knowledge of its syntactic constructs. The objective of this research is to develop on-line syntactic aids to assist the users of such languages. To achieve this objective, three functional capabilities will be developed and evaluated: text display, assistance in source statement preparation, and system data base maintenance. (1) The textual display facility will provide a capability to inform the on-line user about the system. The subject matter of the displayed messages will include: descriptive information on the use of the facility, syntax information pertaining to the source language, information on the structure of the language. (2) The source statement preparation facility provides the user with a capability for on-line statement preparation in an assisted or unassisted mode. Input assistance means that the user, upon specifying a language statement, is provided automatically with statement components and is merely required to complete the statement with specific parameter values. (3) The system data base facility is responsible for maintaining text and directing the man/machine dialogue. The overall structure of the on-line facility is sufficiently general to accommodate a wide range of computer language syntactic structures. The initial use of this facility is to aid the users of the Information Processing System Simulator (IPSS) in preparing simulation models.

T. G. DeLutis, J. D. Smith (Sponsor: National Science Foundation. Grant SIS-75-21648)

CHARACTERIZATION AND EVALUATION OF DATA BASE ORGANIZATION

The performance of an information system depends on the various systems components and their interactions. Due to unavailability of systematic characterization and analysis procedures, data base content and user request stream, two of the major contributing factors affecting system performance are either ignored or are considered at a macroscopical level in the design and evaluation process. In this research, a methodology is being developed to characterize these two components. The user request stream component is characterized by a set of probability distribution functions that describe the frequencies of different types of queries. The data base content component is characterized by another set of probability distribution functions that describe the pattern of occurrences of data base keywords. These characterizations are being developed so that the information system analyst will be able to formulate analytical models to describe his system components and their interactions at a more realistic level. Simulation techniques are to be used to evaluate these models. The goal of this research is to develop a set of descriptive facilities, performance measures and associated procedures based on the aforementioned characterizations.

T. G. DeLutis, P. M. K. Wong (Sponsor: National Science Foundation. Grant SIS-75-21648)

A METHODOLOGY OF THE PERFORMANCE EVALUATION OF DATA BASE BEHAVIOR UNDER SYSTEM USAGE

Recent developments in computer hardware and software technology have made feasible the organization, storage and retrieval of massive amounts of integrated data. Software systems known as data base management systems (DBMSs) control all record storage and retrieval activities by translating the application's service requests into activities associated with the computer system data management facilities. The DBMS data structures which support the characteristically diverse and dynamic user population must display operational efficiency in order that the total system meet its response time and throughput commitments. The goal of this research is to formulate a methodology which characterizes DBMSs for the purpose of evaluating their behavior under system usage, and to provide a realization of the methodology which executes in a discrete event digital simulation environment. Three specific objectives have been identified: (1) the specification of a set of characteristics of data base systems which are identifiable with the DBA function and DBMS usage. This requires (a) the identification of a set of features which describe the schema, DMLs, application programs and essential DBMS functions (such as buffer management, interaction with the system's IOCS, etc.), and (b) the specification of a model definition language which incorporates these characteristics. (2) The identification of a set of model outputs which provides the modeler with insight into the behavior of the data base system. The function of these outputs is to identify salient behavior characteristics of a DBMS model in terms identifiable to a user. The purpose of these outputs is to aid the DBM in evaluating the performance of the system. (3) The specification of a set of algorithms which relates the model's definitional parameters to the outputs. The methodology consists of declarative and procedural components for the above. The methodology definitions and outputs will be coordinated with the data obtainable by the data base administrator (DBA).

A realization of the methodology consists of the specification of the model definition language and the algorithms for transforming the declarative and procedural characterizations into outputs which relate to the behavior of the model. This realization will be an extension of the functional capabilities provided by the Information Processing System Simulator (IPSS).

T. G. DeLutis, J. D. Smith (Sponsor: National Science Foundation. Grant SIS-75-21648)

APPLICATION CONSTRAINTS ON THE GENERATION OF TEST WORKLOADS

A general taxonomy for performance evaluation efforts involving benchmark workloads is being developed. Valid benchmark generation techniques will then be described for each workload application in the taxonomy. Thus, a means will exist for both evaluating the validity of existing workload generation methodologies and for developing new valid methodologies.

S. A. Mamrak, The Ohio State University; M. D. Abrams, National Bureau of Standards

THE MODELING OF A LARGE ON-LINE INFORMATION SYSTEM

The object of this research is to model a large on-line IS&R system from the point of view of identifying the problems associated with such systems and the simulation language features that facilitate the investigation of these problems. The modeled system is the Ohio College Library Center (OCLC) information system which is a large, one-line multiprocessor facility handling in excess of 1200 terminals. The system is extremely dynamic in its growth characteristic, for example, its data base currently contains 2.2 million bibliographic records and is substaining a 1% per week rate of growth. The modeling effort is comprised of four major phases, each with the following objectives:

1. Model Synthesis - description of hardware configuration, data base storage structure, operating system control sequences and query processing requirements;

2. Model Validation - statistical testing of random number generators and various dynamic attributes associated with the model;

3. Model Verification - testing the accuracy of the various system's functions such as memory management and task scheduling, and verifying the software and hardware utilization statistics; and

4. Model Investigation - the effects of various model parameters, such as, alternative hardware configuration, data base storage structures and scheduling algorithms are investigated.

In this project, the Information Processing System Simulator (IPSS) is being employed as part of the evaluative effort. An additional benefit from this research is the identification and evaluation of simulator features which enhance the model synthesis and analysis endeavor relative to this class of information processing systems.

T. G. DeLutis, J. E. Rush, P. M. K. Wong

THE DESIGN OF CRYPTOGRAPHY BASED SECURE FILE SYSTEMS

The design of a secure file system based on user controlled cryptographic transformations was investigated. Several types of protection policies such as: compartmentalized, hierarchical, and data dependent were discussed. The design principles of the system assure its security even under severe conditions such as "bypassing" the access control mechansim, or failure of the identification process.

Several cryptographic schemes based on these design principles were investigated. They differ in terms of "user convenience" and other criteria, thus providing the designer with the necessary trade-off's to make correct design decisions.

E. Gudes, J. Rothstein, H. Koch, S. Zweben

SOFTWARE ENGINEERING PRINCIPLES FOR MULTIPROCESSING SYSTEMS

Not until a system is operational does the designer sometimes discover that excessive delays in multiprocessing occur due to the synchronization. Many times it is not clear whether the synchronization can be improved without having interference occur. The main objective of this research is to develop guidelines and rules that will aid designers in building systems that can be effectively and efficiently multiprocessed. This includes methods whereby one can determine which processes can be multiprocessed and, prior to implementation, the amount of multiprocessing that a system can perform on an application. By meeting the objectives of this research, all people who interact with the system will benefit directly -- namely, the users, systems designers and the data base administrator. Some of these benefits are: increased integrity and throughput, decreased response time, well-defined rules to identify which processes can be multiprocessed and where synchronization statements should be placed, and methods to predict multiprocessing performance before implementation.

H. S. Koch

RESPONSE TIME PREDICTION AS A NETWORK RESOURCE SHARING SERVICE

A dynamic response time prediction methodology is being developed in which "micro" (very small) benchmark jobs are run at the time an actual response inquiry is made, and prediction is based on the results of the response time for the micro benchmark. The format and feasibility of this type of dynamic prediction will be investigated, for incorporation into a user-oriented cost-benefit module. It's use will be compared to a more static type of response time prediction for network environments developed in earlier work.

S. A. Mamrak

COMPUTER GRAPHICS

The graphic language is an essential and powerful tool for the communication of information. A principal use of the language, in engineering and other technical areas, is for the precise description of 3-dimensional shape. But except for the elementary geometric forms, for which mathematical formulas exist, computer definition of the shape of objects is difficult. Research is under way to devise easy-to-use systems for the definition, manipulation, and display of geometric shapes, and the computer solution of relationships between them.

The graphic language can be a valuable tool for computation. A graphic analog is, for many applications, less time-consuming than its algebraic or numeric counterpart, less susceptible to accidental error, and more illuminating with respect to the relationships involved. In some instances, the graphic solution is the only one available. The development of user-oriented languages for the construction of problem-solving analogs is under study.

C. H. Kearns

X. COMPUTER ARCHITECTURE AND NETWORKS

DATABASE MACHINE ARCHITECTURES

This work is concerned with building database machines by taking advantage of recent advances in memory and processor technology. The classical approach to building Database Management Systems (DBMS) has a high software overhead with resultant inefficiency and unreliability. The object of this research effort is to avoid performance bottlenecks inherent in current DBMS by designing special-purpose hardware which can directly support various data models, e.g. relational, network, attribute based, etc. The security aspect of DBMS is also integrated in the hardware design to ensure that unauthorized accesses to the database are prevented at all times.

K. Kannan, D. K. Hsiao (Sponsor: Office of Naval Research. Grant N00014-75-0573)

DESIGN AND OPERATIONS OF A SECURE COMPUTER SYSTEM

The main goal of the research is to design a general purpose computer system which has security and protection of information as its integral components. The main components of the system and its operations to be protected are communications with remote users, data transmission, processing, storage and retrieval and multilevel sharing of computer information. Security in the system has been achieved by a unified application of cryptography and access control combined with some special procedures which improve either the security of the system or its operational efficiency.

Cryptographic protection in the communication system (user identification, user authentication, data transmission) is implemented with a special encoding/decoding device at each terminal. That device encodes data coming from the terminal and decodes data coming from the central site. Cryptographic protection in main memory, on external files and during processing of data is provided by the security control device which is placed between main memory and the CPU. Besides cryptographic protection this device also performs access control and special procedures.

The secure computer system has been designed according to an extensive list of threats and illegal activities. It has all its hardware components and operating procedures protected: terminals, communication lines, external files, main memory, identification and authentication of remote users, data communications, data base security and processing security.

M. T. Liu, S. Muftic

DESIGN CONSIDERATIONS FOR DISTRIBUTED DATA BASES IN COMPUTER NETWORKS

This research extends the concepts of the data base system to the distributed computer networks and tries to close the gap between the centralized data base system and the distributed data base system. A distributed data base model has been proposed to share its data collection by a geographically scattered community of users who exhibit the geographical locality of reference.

So far, other research in the area of distributed data base area has focused only on the remote accessing of files scattered in the computer network. The programs access the remote or local files directly. The two basic objectives of the data base -- the removal of redundancy and the invariability of the programs to changes of storage structure and access methods -- have not been considered. This research introduces the idea of the sub-DB which interact hierarchically to fulfill these two objectives and thus closes the gap between the centralized and the distributed systems.

Based on this model, the optimal locations of the sub-DB's are computed by dynamic programming approach. The efficiency and the storage requirements for this solution approach can be improved if the sparseness of remote access can be taken into account. Finally, the assumption of the strictly hierarchical access pattern is relaxed and the possibility of redundant sub-DB is considered.

M. T. Liu, T. T. Cheng

ANALYSIS AND SIMULATION OF THE MIXED VOICE/DATA TRANSMISSION SYSTEM (MVD) FOR COMPUTER COMMUNICATION

A novel model of Mixed Voice/Data (MVD) transmission system for computer communication has been proposed previously. This research concerns the analysis and simulation aspects of such a system. In the analytic aspect of the MVD system, four areas have been treated: (1) the probability density functions of both talking- and silent-period have been constructed using sampled measurements on international satellite telephone circuits, (2) the interfering mechanism and utilization overhead of the system have been analyzed using a probabilistic model, (3) the queueing phenomenon of data packets and the measures of system effectiveness have been derived from a set of two-dimensional differential difference equations, and (4) optimum packet size to achieve maximum information throughput, reduce overhead, and alleviate bad queueing condition was found. In the simulation aspect, a GPSS V/6000 model has been built and run on a CDC Cyber 70/72. A first sketch of system implementation using INTEL MCS-80 microcomputer system is also obtained.

M. T. Liu, J. T. Wang

SYSTEM DESIGN OF THE DISTRIBUTED LOOP COMPUTER NETWORK

The Distributed Loop Computer Network (DLCN) is envisioned as a powerful distributed computing system which interconnects midi/mini/micro-computers, terminals and other peripherals through careful integration of hardware, software and a loop communication network. The major goals of DLCN are to provide efficient, inexpensive, reliable and flexible service to a localized community of semi-autonomous, small-scale computer users, who operate in an environment like that frequently found today in many industrial, commercial and university areas.

Research concerning the Distributed Loop Computer Network has been mainly in three areas: the communication network, the message protocol, and the distributed network operating system. For the loop communication network, a novel variable-length message transmission mechanism was developed, its implementation in the loop interface hardware was treated, and its superior performance was verified by GPSS computer simulation. A bit-oriented message communication protocol (DLMCP) which operates with distributed control and handles four message types under one common format was designed next. Besides user information transfer, this protocol supports automatic hardware-generated message acknowledgment, error detection and recovery, and network control and distributed operating system functions. The network operating system itself (DLOS) was designed to give the user the illusion he is operating on a single, very powerful machine with many resources. Thus facilities are provided for interprocess communication by process name, global process control and calling of remote programs, generalized data transfer, alterable multi-linked process control structures, distributed resource management, and logical I/O transmission in a distributed file system. With these many features, it should be easy for DLCN to realize its goal of becoming a powerful, unified distributed computing system.

M. T. Liu, C. C. Reames

XI. COMPUTATION THEORY

TOWARD AN ARITHMETIC FOR CELLULAR AUTOMATA AND PARALLEL COMPUTATION

The earlier number system studied comprised integers only, and it was not clear how non-integral numbers could be represented. We have now shown how to represent all numbers of the form $N(2^{-n})$ for all positive integers N and n, i.e. all numbers in base 2 with a finite "decimal part", and have proved uniqueness for the representation. The string is finite if and only if the number represented is an integer. In other cases, after a finite or zero non-repeated substring, the rest of the string is periodic, and the periodic part is the same as the period of 2^{-n}. While no way has yet been found to find the expansion of a general rational number, p/q, the above gives arbitrarily close binary approximations to it. All the rules earlier derived for manipulating finite strings apply to these infinite ones unchanged.

J. Rothstein

POLYNOMIAL TIME APPROXIMATIONS OF P-HARD PROBLEMS

For many problems of practical interest there are no known algorithms that can be executed in polynomial time. We look for certain types of approximations that are polynomial-time computable. We make several new definitions of approximation and try to find algorithms for well known problems that produce good approximations in a reasonable time. We also study the theoretical relationships of approximations, seeing if they are transferable from one problem to another.

Another task is to separate those problems which are approximatable in some way from those that are not. Thus we wish to classify P-hard problems in a new way. As an adjunct to this work we look for evidence that humans react to problems of this type differently depending on whether they are approximatable or not.

D. J. Moore

APPENDIX A

COMPUTER AND INFORMATION SCIENCE COURSE LISTING

BY NUMBER AND TITLE

100 Computers in Society

201 Elementary Digital Computer Programming

211 Computer Data Processing I

212 Computer Data Processing II

221 Programming and Algorithms I

222 Programming and Algorithms II

294 Group Studies

294A/223 Introduction to Computer Systems

294D Programming the IBM System/360-370

311 Introduction to File Design and Analysis

411 Design of On-Line Systems

422 Topics in Computing for Engineers

505 Fundamental Concepts of Computer and Information Science

509 Survey of Computer & Information Science for High School Teachers

541 Survey of Numerical Methods

542 Introduction to Computing in the Humanities

543 Intermediate Digital Computer Programming

548 Computer Science for High School Teachers

549 Numerical Analysis for High School Teachers

550 Introduction to Information Storage and Retrieval

555 Survey of Programming Languages

610 Principles of Man-Machine Interaction

640 Numerical Analysis

641 Computer Systems Programming I

642 Numerical Linear Algebra

643 Linear Optimization Techniques in Information Processing

644 Advanced Computer Programming

652 Modeling of Information Systems

675 Digital Computer Organization

676 Minicomputer Evaluation and Selection

677 Computer Networks

680 Data Structures

693 Individual Studies

694 Group Studies

694A Interactive Computer Graphics

705 Mathematical Foundation of Computer and Information Science

706 Information Theory in Behavioral Science

712 Man-Machine Interface

720 Introduction to Linguistic Analysis

726 Theory of Finite Automata

727 Turing Machines and Computability

728 Topics in Theory of Computing

730 Basic Concepts in Artificial Intelligence

735 Statistical Methods in Pattern Recognition

740 Computer Systems Programming II

741 Comparative Operating Systems

745 Numerical Solution of Ordinary Differential Equations

746 Advanced Numerical Analysis

750 Modern Methods of Information Storage & Retrieval

751 Fundamentals of Document-Handling Information Systems

752 Techniques for Simulation of Information Systems

753 Theory of Indexing

754 Language Processing for Information Storage and Retrieval

755 Programming Languages

756 Compiler Design & Implementation

760 Selected Topics in the Mathematics of Information Handling

765 Theory of Management Information Systems

775 Advanced Computer Organization

780 File Structures

781 Aspects of Computer Graphics Systems

788 Intermediate Studies in Computer & Information Science

788.01 Theory of Information

788.02 Information Storage & Retrieval

788.03 Theory of Automata

788.04 Artificial Intelligence

788.05 Pattern Recognition

788.06 Computer Systems Programming
788.06A OS-MVT

788.07 Programming Languages

788.08 Computer Organization

788.09 Numerical Analysis

788.10 Man-Machine Interaction

788.11 Formal Languages

788.12 Management Information Systems

788.13 Biological Information Processing

788.14 Socio-Psychological Aspects of Information Processing

793 Individual Studies

797 Interdepartmental Seminar

805 Information Theory in Physical Science

806 Cellular Automata & Models of Complex Systems

812 Computer & Information Science Research Methods

820 Computational Linguistics

835 Special Topics in Pattern Recognition

840 Operating System Implementation

845 Numerical Solution of Partial Differential Equations

850 Theory of Information Retrieval I

851 Theory of Information Retrieval II

852 Design and Analysis of Information Systems Simulations

855 Current Topics in Programming Languages

865 Seminar on Socio-Psychological Aspects of the Information Sciences

880 Advanced Theory of Computability

888 Advanced Studies in Computer & Information Science

888.01 Theory of Information

888.02 Information Storage & Retrieval

888.03 Theory of Automata

888.04 Artificial Intelligence

888.05 Pattern Recognition

888.06 Computer Systems Programming

888.07 Programming Languages

888.08 Computer Organization

888.09 Numerical Analysis

888.10 Man-Machine Interaction

888.11 Formal Languages

888.12 Management Information Systems

888.13 Biological Information Processing

888.14 Socio-Psychological Aspects of Information Processing

889 Advanced Seminar in Computer & Information Science

894 Group Studies

899 Interdepartmental Seminar

999 Research

APPENDIX B

COMPUTER AND INFORMATION SCIENCE FACULTY

Marshall C. Yovits, Ph.D., (Yale University).
Professor and Chairman of Department of Computer and Information Science and Professor of Electrical Engineering. Director, C.I.S. Research Center. Information systems, theory of the flow of information, self-organizing systems.

Ranko Bojanic, Ph.D., (Mathematical Institute of the Serbian Academy of Science).
Professor of Computer and Information Science and Professor of Mathematics. Mathematical analysis, theory of approximation.

Charles A. Csuri, M.A., (The Ohio State University)
Professor of Computer and Information Science and Professor of Art. Advancement of computer graphics technology in software and hardware (language algorithms, data generation or inputs), use of computer technology in telecommunications.

Richard I. Hang, M.S., (The Ohio State University).
Professor of Computer and Information Science and Professor of Engineering Graphics. Computer graphics, engineering application of computers.

Clyde H. Kearns, M.S., (The Ohio State University).
Professor of Computer and Information Science and Professor of Engineering Graphics. Computer graphics, engineering application of computers.

Robert B. McGhee, Ph.D., (University of Southern California).
Professor of Computer and Information Science and Professor of Electrical Engineering. Control theory, switching theory, logical design.

Harold B. Pepinsky, Ph.D., (University of Minnesota).
Professor of Computer and Information Science and Professor of Psychology. Clinical and socio-cultural psychology.

Roy F. Reeves, Ph.D., (Iowa State University).
Professor of Computer and Information Science and Professor of Mathematics. Director, Instruction and Research Computer Center. Numerical analysis and programming.

Jerome Rothstein, A.M., (Columbia University).
Professor of Computer and Information Science and Professor of Biophysics. Informational problems in science, methodology, biocybernetics.

Charles Saltzer, Ph.D., (Brown University).
Professor of Computer and Information Science and Professor of Mathematics. Coding theory, numerical analysis, automata theory.

Hugh Atkinson, M.A., (University of Chicago).
Associate Professor of Library Administration and Director of Libraries. Library on-line automation, data processing for libraries, technical service processing models.

Kenneth Breeding, Ph.D., (University of Illinois).
Associate Professor of Computer and Information Science and Associate Professor of Electrical Engineering. Computer organization and switching theory.

H. William Buttelmann, Ph.D., (University of North Carolina).
Associate Professor of Computer and Information Science
Automata theory, computer architecture and programming languages.

Balakrishnan Chandrasekaran, Ph.D., (University of Pennsylvania).
Associate Professor of Computer and Information Science. Pattern recognition and artificial intelligence, learning automata theory, finite memory decision theory and game theory.

Ronald L. Ernst, Ph.D., (University of Wisconsin).
Associate Professor of Computer and Information Science and Associate Professor of Psychology. Human performance theory and engineering, complex information processing and systems evaluation.

Clinton R. Foulk, Ph.D., (University of Illinois).
Associate Professor of Computer and Information Science. Programming languages, systems programming, programming heuristics.

David K. Hsiao, Ph.D., (University of Pennsylvania).
Associate Professor of Computer and Information Science. Systems programming, information storage and retrieval systems, file systems, data base management systems, access control and privacy protection of data, data definition language and processor, system architectures.

Douglas S. Kerr, Ph.D., (Purdue University).
Associate Professor of Computer and Information Science. Numerical analysis and programming.

Ming-Tsan Liu, Ph.D., (University of Pennsylvania).
Associate Professor of Computer and Information Science. Computer organization, switching and automata theory, mathematical programming, computer architecture, pseudo-Boolean programming, threshold logic.

Anthony E. Petrarca, Ph.D., (University of New Hampshire).
Associate Professor of Computer and Information Science. Automatic indexing, chemical structural information processing, automated search systems, other aspects of information storage and retrieval.

James B. Randels, Ph.D., (The Ohio State University).
Associate Professor of Computer and Information Science and Assistant Director, Learning Resources Computer Center. Computer operating systems and utilities, telecommunications applications, subroutine libraries, programming languages.

James E. Rush, Ph.D., (University of Missouri).
Adjunct Associate Professor of Computer and Information Science. Indexing theory, automated language processing, organization of information, and parallel processing.

Celianna I. Taylor, B.S.L.S., (Graduate School of Library Science, Case-Western Reserve University).
Senior Research Associate and Associate Professor of Library Administration. Information dissemination and utilization systems, information centers, library systems and management.

Lee J. White, Ph.D., (University of Michigan).
Associate Professor of Computer and Information Science and Associate Professor of Electrical Engineering. Mathematical programming, data structures, organization of information.

Ronald L. Wigington, Ph.D., (University of Kansas).
Adjunct Associate Professor of Computer and Information Science and Director of R. & D., Chemical Abstracts Service. Computer system design.

Thomas G. DeLutis, Ph.D., (Purdue University).
Assistant Professor of Computer and Information Science. Design and evaluation of information systems, systems programming.

Donald L. Kalmey, Ph.D., (The Ohio State University).
Assistant Professor of Computer and Information Science. Numerical analysis, computer architecture and organization, programming.

Harvey S. Koch, Ph.D., (Pennsylvania State University).
Assistant Professor of Computer and Information Science. Data definition language, data base management, programming languages and compiler design.

Anthony P. Lucido, Ph.D., (Iowa State University).
Assistant Professor of Computer and Information Science. Computer architecture, compiler design, interactive computer graphics.

Sandra Mamrak, Ph.D., (University of Illinois).
Assistant Professor of Computer and Information Science. Performance evaluation, computer networks, systems programming.

Howell H. W. Mei, Ph.D., (Cornell University). Appointed Autumn 1976.
Visiting Assistant Professor of Computer and Information Science. Nonlinear optimization, nonlinear systems of equations, operating systems design and algorithm design.

Daniel J. Moore, Ph.D., (University of Kansas).
Assistant Professor of Computer and Information Science. Complexity theory, recursion theory, artificial intelligence.

Kevin C. O'Kane, Ph.D., (Pennsylvania State University).
Assistant Professor of Computer and Information Science and Assistant Professor of Allied Medical Professions. Coordinator, Graduate Training Program in Biomedical Computing and Information Processing. Biomedical computing, computerized medical data base systems.

Lawrence L. Rose, Ph.D., (Pennsylvania State University).
Assistant Professor of Computer and Information Science. Information retrieval, simulation, data structures, programming languages.

Bruce Russell, Ph.D., (National University of Ireland). Appointed Autumn 1976.
Visiting Assistant Professor of Computer and Information Science. Formal semantics of programming languages and data structures, automatic generation of implementations, programming methodologies, theories of representations and automatic generation of representations from abstract definitions.

Norman K. Sondheimer, Ph.D., (University of Wisconsin).
Assistant Professor of Computer and Information Science. Natural language processing, artificial intelligence, information storage and retrieval.

Stuart H. Zweben, (Purdue University).
Assistant Professor of Computer and Information Science. Programming languages, compilers, data structures, operating systems.

Ernest Staveley, B.S., (U.S. Naval Postgraduate School).
Administrative Assistant and Assistant Director, C.I.S. Research Center.

APPENDIX C

COMPUTER AND INFORMATION SCIENCE SEMINAR SERIES

July 10, 1975 "Classification and Feature Selection Algorithms for Invariant Pattern Recognition with Application to Aircraft Identification," Sargur N. Srihari, Ph.D. Candidate, Computer and Information Science, The Ohio State University.

July 17, 1975 "Improvement of Automatic Vocabulary Control in Indexes Derived from Natural Language Text," William S. Stalcup, Ph.D. Candidate, Computer and Information Science, The Ohio State University.

July 24, 1975 "Some Models for Automatic Document Classification," Gautam Kar, Ph.D. Candidate, Computer and Information Science, The Ohio State University and Lee J. White, Associate Professor, Computer and Information Science, The Ohio State University.

July 31, 1975 "A Data Secure Computer Architecture," Richard I. Baum, Ph.D. Candidate, Computer and Information Science, The Ohio State University.

August 7, 1975 "Prefix Encoding with Arbitrary Cost Symbols," Viswanathan Santhanam, Ph.D. Candidate, Computer and Information Science, The Ohio State University

August 12, 1975 "Some Maxmin Location and Pattern Classification Problems: Theory and Algorithms," Balakrishnan Dasarathy, Ph.D. Candidate, Computer and Information Science, The Ohio State University.

August 14, 1975 "Recent Progress on Attribute-Based Data Base Systems Research," Douglas S. Kerr, Associate Professor, Computer and Information Science, The Ohio State University.

September 25, 1975 "Air Force Computer Selection Procedures," James M. Cameron, Assistant Professor of Mathematical Sciences, Denison University.

October 2, 1975 "On-Line, the Library and You," Mary Jo Arnold, Engineering Librarian, The Ohio State University.

October 8, 1975 "Human Factors Experiments in Structured Programming," Ben Shneiderman, Assistant Professor, Department of Computer Science, Indiana University.

October 16, 1975 "Comments on Psychological and System Considerations in Structured Program Construction," Ronald L. Ernst, Associate Professor, Computer and Information Science and Psychology, The Ohio State University.

October 20, 1975 "On the Parallel Evaluation of Rational Expressions," Amnon Barak, Assistant Professor of Computer Science, The Hebrew University of Jerusalem.

October 23, 1975 "The Languages of Policy," Harold B. Pepinsky, Professor of Psychology and Professor of Computer and Information Science, The Ohio State University.

October 30, 1975 "Comparative Studies for the Performance Evaluation of Methods for Solving Systems of Non-Linear Equations," Donald L. Kalmey, Assistant Professor, Computer and Information Science, The Ohio State University.

November 4, 1975 "Some Mathematical Programming Approaches to Joint Coordination Robot Locomotion," Robert B. McGhee, Professor of Electrical Engineering and Professor of Computer and Information Science, The Ohio State University.

November 13, 1975 "Data Base Access Control in the Presence of Context-Dependent Protection Requirements," Cheng-Jen Nee, Ph.D. Candidate, Department of Computer and Information Science, The Ohio State University.

January 8, 1976 "Languages for Specifying Protection Requirements in Data Base Systems--A Semantic Model," Dr. H. Rex Hartson, Department of Computer and Information Science, The Ohio State University.

January 15, 1976 "Data Base Support of University Administrative Systems," William B. McKelvey, Director, University Systems Development, The Ohio State University.

January 27, 1976 "Fast Riccati Algorithms," D. G. Lainiotis, Professor and Chairman, Department of Electrical Engineering, SUNY Buffalo.

January 29, 1976 "Associative and Parallel Processors," Kenneth J. Thruber, Computer Science Department, University of Minnesota and Product Development Group, Sperry Univac Defense Systems Division.

February 5, 1976 "Biomedical Engineering Research in the US and Europe," Herman R. Weed, Director, Biomedical Engineering Center and Professor, Department of Electrical Engineering, The Ohio State University.

February 12, 1976 "Generation of English from a Semantic Network," Stuart C. Shapiro, Assistant Professor, Department of Computer Science, Indiana University.

February 19, 1976 "Designing the BASIS Interactive DBMS to Function on Several Different Computers," John B. Fried, Manager, Information Systems Section, Battelle Columbus Laboratories.

March 4, 1976 "System Design of the Distributed Loop Computer Network," Cecil C. Reames, Ph.D. Candidate, Department of Computer and Information Science, The Ohio State University.

March 10, 1976 "Language Measurement," Jean E. Sammet, Federal Systems Division, IBM Corporation.

March 15, 1976 "Microprocessors: A New Direction in Computer Science," Alfred C. Weaver, Prospective Faculty Member, Department of Computer Science, University of Illinois at Urbana-Champaign.

March 30, 1976 "On Finding Exact and Approximate Solutions to Some Problems," Dr. Teofilof Gonzalez, Prospective Faculty from University of Oklahoma.

April 1, 1976 "Ethical Considerations of Computers in Medicine," E. R. Gabrieli, M.D., Director, Clinical Information Center, E. J. Meyer Memorial Hospital, SUNY Buffalo.

April 2, 1976 "Dynamic Memory Management Systems," Dr Dennis Ting, Pennsylvania State University.

April 6, 1976 "Symbolic Algebraic Manipulation on a Computer," David Yun, IBM Thomas J. Watson Research Center.

April 8, 1976 "Communication Systems, LSI, and Microprocessors," R. W. Lucky, Bell Telephone Laboratories, Holmdel, NJ.

April 9, 1976 "Computation of a Subclass of Inferences," Ralph M. Weischedel, Visiting Assistant Professor, University of California-Irvine.

April 15, 1976 "A Hands-On Approach to Teaching Systems Programming," Malcolm Lane, Department of Statistics and Computer Science, West Virginia University.

April 22, 1976 "Application of Computers in the Chemical Industry," Carlos M. Bowman, Director, Computation Laboratory, Dow Chemical USA.

April 28, 1976 "Computer Hardware and Software: Future Developments," Grace M. Hopper, Head, Programming Languages Section, Department of the Navy.

May 6, 1976 "Conputer Techniques in Medical Diagnosis," Caesar Caceres, M.D., Clinical Systems Associates.

May 13, 1976 "Quantitative Research on Computer Programming," James L. Elshoff, Computer Science Department, Research Laboratories, General Motors Corporation.

May 17, 1976 "Sequential/Parallel Matrix Array Languages," Patrick Shen-Pei Wang, School of Information and Computer Science, Georgia Institute of Technology.

May 20, 1976 "Richard Montague's Theories of Natural Language Syntax and Semantics," David Dowty, Department of Linguistics, The Ohio State University.

May 27, 1976 "The Status of Women in Academic Computer Science," Sandra Mamrak, Department of Computer and Information Science, The Ohio State University.

June 3, 1976 "Towards a State-Based Conceptual Representation for Natural Language," Nicholas Cercone, Department of Mathematics and Computing Sciences, Old Dominion University.

APPENDIX D

RELATED ACTIVITIES OF THE STAFF OF

COMPUTER AND INFORMATION SCIENCE RESEARCH CENTER

B. Chandrasekaran presented an invited talk entitled "Dimensionality and Sample Size in Pattern Classification: A Retrospective Look" to the Michigan State University Computer Science Department, November 25, 1975.

B. Chandrasekaran was the organizer and chairman of a session on "Performance Evaluation of Computer Systems Via Simulation" at the Pittsburgh Conference on Modeling and Simulation, Pittsburgh, April 27, 1976.

B. Chandrasekaran presented an invited paper entitled "Moulding Computer Clay - Steps Towards a Computer Graphics Sculptors' Studio" (Co-author: Richard E. Parent) at the Workshop on Pattern Recognition and Artificial Intelligence, Cape Cod, Massachusetts, June 2, 1976.

B. Chandrasekaran presented a paper entitled "On Balancing Decision Functions" (Co-author: Anil K. Jain) at the International Information Theory Symposium, Ronneby, Sweden, June 21-24, 1976.

E. Gudes presented a paper entitled "The Application of Cryptographic Transformations for Data Base Security" (Co-authors: Harvey S. Koch and Fred A. Stahl) at the National Computer Conference, New York City, June 8, 1976.

D. L. Kalmey presented "Potentially Nonconvergent Regions Inherent in Systems of Nonlinear Equations" (Co-authors: D. S. Kerr and L. J. White) at the Society for Industrial and Applied Mathematics 1976 National Meeting, Chicago, June 16, 1976.

D. S. Kerr chaired a session on Computer Science Curriculum at the ACM SIGCSE Sixth Technical Symposium on Computer Science Education sponsored by the Association for Computing Machinery Special Interest Group on Computer Science Education, Williamsburg, Virginia, July 26-27, 1975.

D. S. Kerr presented a paper entitled "Recent Results on the Attribute Based Data Model - A Tutorial" at the Very Large Data Bases Conference, Framingham, Massachusetts, September 22-24, 1975. Dr. Kerr was also Proceedings Editor for the Conference.

D. S. Kerr has been elected Vice Chairman of the Special Interest Group on Computer Science Education of the Association for Computing Machinery.

H. S. Koch has been appointed as Chairman of an Advisory Panel (to Evaluate the Processing and Handling of Claims in the Bureau of Workmen's Compensation and the Industrial Commission) to the Ohio State Senate Joint Select Committee on Workmen's Compensation.

M. T. Liu presented the following papers at the 1975 International Computer Symposium held in Taipei, Taiwan, August 20-22, 1975:

"The Design of the Distributed Loop Computer Network" (Co-author: Cecil C. Reames) and

"A Novel Model for a Mixed Voice/Data Transmission System for Computer Communication" (Co-author: Jin-tuu Wang).

M. T. Liu presented the following papers at the Third Annual Symposium on Computer Architecture in Clearwater, Florida, January 19-21, 1976:

"System Design of a Grammar-Programmable High-Level-Language Machine" (Co-author: Serge Fournier) and

"Design and Simulation of the Distributed Loop Computer Network (DLCN)" (Co-author: Cecil C. Reames).

A. P. Lucido was Technical Program Chairman of the Second Annual Conference on Computer Graphics and Interactive Techniques (sponsored by SIGGRAPH of the Association for Computing Machinery), Bowling Green State University, June 25-27, 1976. Professor Lucido also edited the refereed Proceedings of the Conference.

S. A. Mamrak presented an invited talk entitled "Computers: What They Can Do for You and to You" to a meeting of directors of the Ohio School Counselors Association (OSCA) sponsored jointly by OSCA and The Engineers Foundation of Ohio, March 5, 1976.

S. A. Mamrak presented a paper entitled "Simulation of Computer Systems: A Tutorial" at the Seventh Annual Pittsburgh Conference on Modeling and Simulation, Pittsburgh, April 26-27, 1976.

D. A. Marik presented a paper entitled "A Grammatical Inference Problem with Application to Pattern Recognition" (Co-author: L. J. White) at the Fourth Annual Computer Science Conference, Anaheim, California, February 10-12, 1976.

D. J. Moore presented the following papers at the Seventh Annual Pittsburgh Conference on Modeling and Simulation, Pittsburgh, April 26, 1976:

"Analysis of Simulation Stability" (Co-authors: D. Miller and J. Thompson) and

"A Simulation of Prehistoric Locational Behavior" (Co-author: L. Zimmermann).

K. O'Kane delivered presentations entitled "A Graduate Training Program in Biomedical Computing and Information Processing" (Co-authors: A. E. Petrarca, R. E. Pengov, and G. L. Trzebiatowski) at the Computer Science Conference in Anaheim, California, February 1976, and at the Second Midwest Conference on Biomedical Engineering in Columbus, Ohio, May 1976.

K. O'Kane was appointed to the Panel of Readers of the Journal of Phi Kappa Phi for publications concerning computer and information science.

K. O'Kane was appointed Data Coordinator for the Ohio State University Comprehensive Cancer Center and the Center's representative to the National Cancer Institute's Committee on a Comprehensive Cancer Patient Data System.

K. O'Kane is a member of the National Cancer Institute's National Conference of Epi-Stat Directors Data Base Committee and Committee on Collaborative Etiologic Studies.

K. O'Kane is a contributing editor to the Journal of Clinical Computing's "Survey of Clinical Computing."

K. O'Kane is a reviewer for the Biomedical Computing Technology Information Center of the Oak Ridge National Laboratory.

A. E. Petrarca presented a paper entitled "Generation of Unique Computer Representations of Stereoisomers from Non-Unique Unambiguous 3-Dimensional Input Descriptions" (Co-authors: G. Williams and Kenneth J. Wells) at the Division of Chemical Information, 170th National Meeting of American Chemical Society, Chicago, Aug. 24-29, 1975.

A. E. Petrarca was elected Alternate Chapter Assembly Representative for the Central Ohio Chapter of the American Society for Information Science (ASIS).

C. C. Reames presented "Design and Simulation of the Distributed Loop Computer Network (DLCN)" (Co-author: Ming T. Liu) at the Third Annual Symposium on Computer Architecture, Clearwater, Florida, January 19-21, 1976.

J. Rothstein co-authored "Bus Automata and Parallel Computation" which was presented by J. Michael Moshell at the 8th Annual Southeastern Symposium on System Theory, Knoxville, April 26-27, 1976.

J. Rothstein presented "Octic Group and Duality between Multiplication and Relativistic Velocity Addition" at the Washington meeting of the American Physical Society, April 26-29, 1976.

J. Rothstein presented a paper entitled "On the Ultimate Limitations of Parallel Processing," co-authored a paper entitled "Parallel Recognition of Patterns: Insights from Formal Language Theory" which was presented by co-author J. M. Moshell; and was chairman of a session entitled "Applications: Image Processing" at the 1976 International Conference on Parallel Processing, Walden Woods, Michigan, August 24-27, 1976.

N. K. Sondheimer presented a paper entitled "SPS: A Formalism for Semantic Interpretation and its use in Processing Prepositions that Reference Space" (Co-author: Doyt L. Perry) at the 13th Annual meeting of the Association for Computational Linguistics, Boston, October 30-November 1, 1975.

N. K. Sondheimer presented an invited talk entitled "The Computational Understanding of Spatial Reference" to the Computer Science Department of Indiana University as part of their Colloquium Series, December 2, 1975.

N. K. Sondheimer was awarded a University Research Grant from the Graduate School for his research on "Development of a Methodology for Natural-Language Machine-Control Elicitation Experiments".

W. S. Stalcup presented a paper entitled "Automatic Vocabulary Control and its Evaluation in Computer-Produced Indexes" (Co-author: Anthony E. Petrarca) at the American Society for Information Science, 38th Annual Meeting, Boston, October 26-30, 1975.

C. I. Taylor became a member of the Data Management Committee of Community Information Referral Science, Inc.

C. I. Taylor chaired the Committee on Information Systems and Information Utilities, Common Cause/Ohio.

C. I. Taylor accepted an invitation to join the Working Group on Information Systems and the Public Interest which is a subgroup of TC9 (Technical Committee on the Relationship between Computers and Society) of the International Federation of Information Processing Societies (IFIPS).

L. J. White presented "An Analysis of a Geographic Data Base Problem" at the Symposium on New Directions and Recent Results in Algorithms and Complexity, Carnegie-Mellon University, Pittsburgh, April 7-9, 1976.

M. C. Yovits was a panelist for the session entitled "Professional Societies Focusing on Computers in Education" at the Association for Computing Machinery Annual Conference, Minneapolis, October 20-22, 1975.

M. C. Yovits was chairman and moderator for a series of three panel sessions entitled "Industry/University Relationships in Computer Science" at the 1976 National Computer Conference, New York City, June 9, 1976.

M. C. Yovits has been elected East Central Regional Representative of the Association for Computing Machinery. His term of office runs through June 30, 1979.

S. H. Zweben served as Secretary of the Central Ohio Chapter of the Association for Computing Machinery, 1975-1976.

S. H. Zweben was elected Vice Chairman of the Central Ohio Chapter of the Association for Computing Machinery for 1976-1977.

S. H. Zweben is a reviewer for IEEE Transactions on Systems, Man, and Cybernetics.

APPENDIX E

PUBLICATIONS OF THE COMPUTER AND INFORMATION SCIENCE RESEARCH CENTER STAFF[1]

CHANDRASEKARAN, B.; GILLENSON, A. A.; CSURI, CHARLES; SCHWARTZ, ROBERT. Facial sketching. Leonardo, Vol. 9, 1976, pp. 126-129.

HSIAO, DAVID K.; BAUM, RICHARD J. Information secure systems. In: Advances in computers. Vol. 14. Academic Press, 1976.

LUCIDO, ANTHONY P. Software systems for computer graphics. IEEE Computer, Vol. 9, No. 8, August 1976, p. 23.

LIU, M. T.; FOURNIER, S. System design of a grammar-programmable high-level language machine. In: Conference Preceedings of the Third Annual Symposium on Computer Architecture, Clearwater, Florida, Jan., 1976, p. 122.

LIU, M. T.; REAMES, C. C. Design and simulation of the distributed loop computer network (DLCN). In: Conference Proceedings of the Third Annual Symposium on Computer Architecture, Clearwater, Florida, Jan., 1976, pp. 124-129.

LIU, M. T.; REAMES, C. C. The design of the distributed loop computer network. In: Proceedings of the 1975 International Computer Symposium, Vol. I, Taipei, Taiwan, August, 1975, pp. 273-283.

LIU, M. T.; WANG, J. T. A novel model for a mixed voice/data transmission system for computer communication. In: Proceedings of the 1975 International Computer Symposium, Vol. I, Taipei, Taiwan, August 1975, pp. 458-468.

MAMRAK, SANDRA. A predictive response time monitor for computer networks. In: Proceedings of the Third International Conference on Computer Communications, Toronto, Canada, August 1976, pp. 626-630.

O'KANE, K. C.; DEMAINE, P. A. D.; HILDEBRANDT, R. J. A proposed integrated regional health information system. Management Informatics, Vol. 4, Fall 1975, pp. 139-147.

O'KANE, D. C.; KELLY, V. M. A review of medical information processing systems. Journal of Clinical Computing, Vol. 4, August 1975, pp. 339-358.

ROSE, LAWRENCE L.; GOTTERER, MALCOLM H. An analysis of file movement under dynamic file management strategies. BIT, Vol. 15, 1975, pp. 304-313.

ROSE, LAWRENCE L. File evaluation in auxiliary storage. Journal of Computer and Information Sciences, Vol. 4, No. 3, September 1975, pp. 197-204.

ROTHSTEIN, JEROME; WEIMAN, CARL. Parallel and sequential specification of a context sensitive language for straight lines on grids. Computer Graphics and Image Processing, Vol. 5, 1976, pp. 106-124.

---

[1] See Appendix F for Publications issued as part of the Computer and Information Science Research Center Technical report series.

SONDHEIMER, NORMAN K. Spatial reference and natural-language machine control. International Journal of Man-Machine Studies, Vol. 8, June 1976, pp. 329-336.

SONDHEIMER, NORMAN K.; PERRY, D. SPS: A formalism for semantic interpretation and its use in processing prepositions that reference space. American Journal of Computational Linguistics, microfiche no. 34, 1975.

STALCUP, W. S.; PETRARCA, A. E. Automatic vocabulary control and its evaluation in computer produced indexes. In: Information Revolution; Proceedings of the 38th ASIS Annual Meeting, Vol. 12, 1975, pp. 73-74.

KSIENSKI, A.A.; LIN, T.; WHITE, L.J. Low frequency approach to target identification. In: Proceedings of the IEEE, Vol: 63, No. 12, December 1975, pp. 1651-1660.

YOVITS, MARSHALL C.; RUBINOFF, MORRIS, eds. Advances in computers. Vol. 14, Academic Press, 1976.

YOVITS, MARSHALL C. Information science in the Soviet Union and the West: A review article. The Library Quarterly, Vol. 46, No. 2, April 1976, pp. 176-179.

YOVITS, MARSHALL C. A theoretical framework for the development of information science. In: Problems of Information Science, edited by A. I. Mikhailov. International Federation of Documentation, Committee on Research on the Theoretical Basis of Information, Moscow, 1975.

PAPERS ACCEPTED FOR PUBLICATION

MAMRAK, SANDRA A.; RANDAL, J. M. An analysis of a software engineering failure. The Computer Journal.

MAMRAK, SANDRA A. The design and development of resource sharing services in computer communications: A survey. In: Advances in Computers, Vol. 16, Academic Press.

MAMRAK, SANDRA A. Dynamic response time prediction for computer networks. Communications of the ACM.

MAMRAK, SANDRA A. A network resource sharing module to augment user cost-benefit analysis. 1976 Symposium on Computer Networks: Trends and Replications.

MAMRAK, SANDRA A. Simulation of computer systems: a tutorial. Proceedings, Seventh Annual Pittsburgh Conference on Modeling and Simulation, April 1976.

MAMRAK, SANDRA A.; MONTANELLI, R. G. The status of women and minorities in academic computer science. Communications of the ACM.

ROSE, LAWRENCE L.; HELLERMAN, HERBERT. Portable character processing in FORTRAN and fixed integer environments. IEEE Transactions on Software Engineering, September 1976.

SONDHEIMER, N. K. Spatial reference and natural-language machine control. International Journal of Man-Machine Studies, 1976.

ZWEBEN, STUART H. A study of the physical structure of algorithms. IEEE Transactions on Software Engineering, 1977.

PAPERS SUBMITTED FOR PUBLICATION

MAMRAK, SANDRA; MONTANELLI, A. G. The status of women and minority faculty in academic computer science. Communications of the ACM.

MAMRAK, SANDRA. Workload characterization using selected pattern techniques. COMPCON, Spring, 1977.

APPENDIX F

TECHNICAL REPORT SERIES

1968

YOVITS, M. C.; ERNST, R. L. Generalized information systems: Some consequences for information transfer. October, 1968. 47p. (OSU-CISRC-TR-68-1) (PB-180 929)

FILLMORE, C. J.; LEHISTE, I. Working papers in linguistics no. 2. November, 1968. 128p. (OSU-CISRC-TR-68-3) (PB-182 596)

FRIED, J. B.; LANDRY, B. C.; LISTON, JR., D. M.; PRICE B. P.; VAN BUSKIRK, R. C.; WASCHSBERGER, D. M. Index simulation feasibility and automatic document classification. October, 1968. 21p. (OSU-CISRC-TR-68-4) (PB-182 597)

ROTHSTEIN, J. Thermodynamics & information: Before, in and beyond quantum mechanics. December, 1968. 21p. (OSU-CISRC-TR-68-5) (PB-183 738)

FINLEY, JR., M. R. The development of a basic language for artificial intelligence. January, 1969. 24p. (OSU-CISRC-TR-68-6) (PB-182 305)

1969

COLOMBO, D. S.; RUSH, J. E. Use of word fragments in computer-based retrieval systems. February, 1969. 7+[9]p. (OSU-CISRC-TR-69-1) (PB-184 104)

WHITE, L. J. Minimum covers of fixed cardinality in weighted graphs. March, 1969. 14p. (OSU-CISRC-TR-69-2) (PB-183 737)

JACKSON, D. M. The construction of retrieval environments and pseudo-classifications based on external relevance. April, 1969. 74p. (OSU-CISRC-TR-69-3) (PB-184 462)

ELLIOT, D. E.; HUANG, S.; LANGENDOEN, D. T.; LEE, P. G.; LEHISTE, I. Working papers in linguistics no. 3. June, 1969. 181p. (OSU-CISRC-TR-69-4) (PB-185 855) (ED-060 689)

BRIGGS, G. E. Reaction time and uncertainty in human information processing. March, 1969. 36p. (OSU-CISRC-TR-69-5) (PB-184 135)

WHITE, L. J.; RUSH, J. E. Linear lists for spiro graphs. June, 1969. 69p. (OSU-CISRC-TR-69-6) (PB-194 402)

PETRARCA, A. E.; LAY, W. M. The double KWIC coordinate index. A new approach for preparation of high-quality printed indexes by automatic indexing techniques. April, 1969. 12 +[17]p. (OSU-CISRC-TR-69-7)*

*Journal of Chemical Documentation, 9, 256 (1969)

YOVITS, M. C. Information science: Toward the development of a true scientific discipline. June, 1969. 27p. (OSU-CISRC-TR-69-8) (PB-187 983)

PETRARCA, A. E.; LAY, W. M. The double KWIC coordinate index. II. Use of an automatically generated authority list to eliminate scattering caused by some singular and plural main index terms. August, 1969. 13p. (OSU-CISRC-TR-69-9)*

MCCULLOUGH, J. L. The acquisition of information across cultures: I. Persuasive role play, counterargument and attitude change. August, 1969. 18p. (OSU-CISRC-TR-69-10) (PB-197 568)

ERNST, R. L.; YOVITS, M. C. Information science as an aid to decision making. September, 1969. 22p. (OSU-CISRC-TR-69-13) (PB-189 666) (ED-054 782)

LANDRY, B. C. An indexing and re-indexing simulation model. June, 1969. 50p. (OSU-CISRC-TR-69-14) (PB-198 115)

SALVADOR, R. Automatic abstracting and indexing. June, 1969. 93p. (OSU-CISRC-TR-69-15)

STEVENS, D. W. A computer program for the reduction of flow tables. June, 1969. 97p. (OSU-CISRC-TR-69-16) (PB-189 679)

COLOMBO, D. S. Automatic retrieval systems and associated retrieval languages. 1969. 69p. (OSU-CISRC-TR-69-17) (PB-198 116)

SCHLESSINGER, J. D.; WHITE, L. J. Optimum prefix encoding. August, 1969. 85p. (OSU-CISRC-TR-69-18) (PB-198 117)

DAY, R.; WHITE, L. J. Hebbian neural simulation: Computer program documentation. (OSU-CISRC-TR-69-19) (PB-204 003)

REEKER, L. H. Extended finite state representation of infinite machines. September, 1969. 36p. (OSU-CISRC-TR-69-20) (PB-187 949)

WILLIAMS, N. T.; ERNST, R. L. A computer simulation of human short-term memory. 1969. 62p. (OSU-CISRC-TR-69-22) (PB-197 874)

BEZDEK, R. R. The acquisition of information across cultures: II. Social science research in a different culture. III. Cross-cohort activity and attitude change, by J. L McCullough. January, 1970. 36p. (OSU-CISRC-TR-69-23) (PB-197 876)

1970

UNKLESBAY, M. K. A one step version of Younger's algorithm for bounded context grammars. 1970. 41p. (OSU-CISRC-TR-70-1) (PB-197 603)

*Proceedings of the American Society for Information Science, Vol. 6, 1969, 277-282.

LI, Y. Information structure and optimal policy. September, 1970. 18p. (OSU-CISRC-TR-70-2) (PB-197 605)

DILLON, S. R. Some procedures for finding substitution property partitions, substitution property covers, and cover pairs for finite state sequential machines. 1970. 79p. (OSU-CISRC-TR-70-3) (PB-197 643)

MATHIS, B. A.; WHITE, L. J.; JACKSON, D. M. Stability analysis of term similarities for information classification theory. July, 1970. 79p. (OSU-CISRC-TR-70-4) (PB-195 376)

MCGHEE, R. B.; DILLON, S. R. A paull-unger procedure for substitution property partitions. April, 1970. 16p. (OSU-CISRC-TR-70-5) (PB-192 120)

DAY, R. G.; WHITE, L. J. Study of a random search method for function minimization. March, 1970. 77p. (OSU-CISRC-TR-70-6) (PB-194 404)

PHARES, R.; WHITE, L. J. Identification of circuits in chemical structures. June, 1970. 7 p. (OSU-CISRC-TR-70-7) (PB-194 396)

HARALSON, K. M.; WHITE, L. J. Optimal prefix codes for ensembles of N equiprobable messages using a binary alphabet. May, 1970. 105p. (OSU-CISRC-TR-70-8) (PB-197 642)

PETRARCA, A. E.; LAITINEN, S. V.; LAY, W. M. Use of the double KWIC coordinate indexing technique for chemical line notations. 1970. 14+[17]p. (OSU-CISRC-TR-70-9) (PB-198 269)

LAY, W. M.; PETRARCA, A. E. Modified double KWIC coordinate index. Refinements in main term and subordinate term selection. 1970. 11+[11]p. (OSU-CISRC-TR-70-10) (PB-197 567) (ED-054 815)

LYONS, J. J. The speed-accuracy trade-off in processing different classes of material. 1970. 38p. (OSU-CISRC-TR-70-11) (PB-198 114)

FILLMORE, C. J.; LEHISTE, I.; MELTZER, D.; TATHAM, M. A.; THOMPSON, S. A. Working papers in linguistics no. 6. September, 1970. 132p. (OSU-CISRC-TR-70-12) (PB-194 829)

ROTHSTEIN, J. Information generalization of entropy in physics. February, 1970. 22p. (OSU-CISRC-TR-70-24) (PB-192 128)

JACKSON, D. M. Basis for an improvability measure for retrieval performance February, 1970. 31p. (OSU-CISRC-TR-70-25) (PB-197 812)

DRACHMAN, B.; EDWARDS, M. L.; FILLMORE, C. J.; LEE, G.; LEE, P.; LEHISTE, I.; ZWICKY, A. M. Working papers in linguistics no. 4. May, 1970. 164p. (OSU-CISRC-TR-70-26) (PB-192 163)

1971

ROTHSTEIN, J. Patterns and algorithms. January, 1971. 8p. (OSU-CISRC-TR-71-1) (PB-197 604)

GROSU, A.; LEE, G. Working papers in linguistics no. 7. February, 1971. [243]p. (OSU-CISRC-TR-71-2) (PB-198 278) (ED-060 688)

CHANDRASEKARAN, B.; KANAL, L. On linguistic, statistical, and mixed models for pattern recognition. March, 1971. 33,A5p. (OSU-CISRC-TR-71-3) (PB-198 279)

WHITTEMORE, B. An example of the application of generalized information systems concepts to the quantification of information in a decision system: The examination of quantified information flow in an industrial control problem. May, 1971. 51p. (OSU-CISRC-TR-71-4) (PB-202 621)

OSTROM, T. M.; STEELE, C. M.; SMILANSKY, J. Information and attitudes: The effects of information context and perceived discrepancy on attitudes. May, 1971. 23p. (OSU-CISRC-TR-71-5) (PB-202 622)

LI, Y. Equipment replacement models: A generalization and extension. May, 1971. 17p. (OSU-CISRC-TR-71-6) (PB-200 548)

ELLIOTT, D.; GEIS, M.; GROSU, A.; NOBEL, B.; ZWICKY, ANN; ZWICKY, ARNOLD. Working papers in linguistics no. 8. June, 1971. 197p. (OSU-CISRC-TR-71-7) (PB-202 724)

BOND, Z. S.; GREGORSKI, R.; KEREK, A.; LEHISTE, I.; SHOCKEY, L.; WENDELL, M. V. Working papers in linguistics no. 9. July, 1971. 232p. (OSU-CISRC-TR-71-8) (PB-204 002) (ED-060 686)

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1972

WHITE, L. J.; GILLENSON, M. L. Optimum center location. January, 1972. 69,A6,B32p. (OSU-CISRC-TR-72-1)

MELTZER, D. Speech synthesis by haar functions with comparison to a terminal analog device. January, 1972. 135p. (OSU-CISRC-TR-72-2)

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OSTROM, T. M.; SLOAN, L. R.; MC CULLOUGH, J. L. Information and attitudes: The effects of repetition and amount of information. April, 1972. 38p. (OSU-CISRC-TR-72-5) (PB-209 802) (ED-061 968)

LEHISTE, I.; MELTZER, D.; SHOCKEY, L.; GREGORSKI, R. Working papers in linguistics no. 12. June, 1972. 88p. (OSU-CISRC-TR-72-6) (PB-210 781) (ED-069 162)

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WEIMAN, C. F. R.; ROTHSTEIN, J. Pattern recognition by retina-like devices. July, 1972. 154p. (OSU-CISRC-TR-72-8) (PB-214 665/2) (ED-065 144)

CHANDRASEKARAN, B.; REEKER, L. H. Artificial intelligence - a case for agnosticism. August, 1972. 28p. (OSU-CISRC-TR-72-9) (ED-069 296)

ROTHSTEIN, J. Loschmidts's and Zermelo's paradoxes do not exist. October, 1972. 9p. (OSU-CISRC-TR-72-10) (PB-213 712/8) (PB-214 666/0)

YOVITS, M. C.; CHANDRASEKARAN, B. Artificial intelligence. December, 1972. 39p. (OSU-CISRC-TR-72-11) (AD-760 782)

HSIAO, D. K.; DENICOFF, M.; BERGART, J. G. An annotated and cross-referenced bibliography on computer security and access control in computer systems. November, 1972. 57p. (OSU-CISRC-TR-72-12) (AD-755 225) (ED-078 879)

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1973

LAY, W. M. The double KWIC coordinate indexing technique: theory, design, and implementation. February, 1973. 250p. (OSU-CISRC-TR-73-1) (PB-228 181/4GI) (ED-072 826)

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STRONG, S. J. An algorithm for generating structural surrogates of English text. April, 1973. 140p. (OSU-CISRC-TR-73-3) (PB-227 071/8GI) (ED-078 844)

HSIAO, D. K. Logical access control mechanisms in computer systems. July, 1973. 24p. (OSU-CISRC-TR-73-4) (AD-765 727/3) (ED-078 880)

WANG, P. T. R. Bandwidth minimization, reducibility decomposition, and triangularization of sparse matrices. September, 1973. 162p. (OSU-CISRC-TR-73-5) (PB-227 396/9GI)

BIERMANN, A. W.; BAUM, R.; KRISHNASWAMY, R.; PETRY, R. E. Automatic program synthesis reports. October, 1973. 62p. (OSU-CISRC-TR-73-6) (AD-771 332/4GI) (ED-086 167)

WYRICK, T ; HSIAO, D. K. System configuration study on the interconnection of the IBM 370/165, DEC System-10 and MICRO 1600/21 computer systems. October, 1973. 26p. (OSU-CISRC-TR-73-7) (AD-770 611/2GI)

1974

HSIAO, D. K.; KERR, D. S.; MC CAULEY III, E. J. A model for data secure systems (Part I). February, 1974. 39p. (OSU-CISRC-TR-73-8) (AD-778 657/7GI) (ED-090 983)

HSIAO, D. K.; KERR, D. S.; NEE, C. J. Context protection and consistent control in data base systems (Part I). February, 1974. 28p. (OSU-CISRC-TR-73-9) (AD-778 658/5GI) (ED-090 982)

BAUM, R. I.; HSIAO, D. K. A data secure computer architecture. July, 1974. 22p. (OSU-CISRC-TR-73-10) (AD-787 580/0GI)

RUSH, J. E.; PEPINSKY, H. B.; LANDRY, B. C.; MEARA, N. M.; STRONG, S. M.; VALLEY, J. A.; YOUNG, C. E. A computer assisted language analysis system February, 1974. 71p. (OSU-CISRC-TR-74-1) (ED-090 948)

REAMES, C. C.; LIU, M. T. Variable-length message transmission for distributed loop computer networks (Part I). June, 1974. 9p. (OSU-CISRC-TR-74-2) (PB-242 913/2GI) (ED-092 152)

KIRSCH, B. M. An improved error diagnositcs system for IBM System/360-70 assembler program dumps. June, 1974. 60p. (OSU-CISRC-TR-74-3) (PB-235 060/1GI) (ED-092 153)

COHEN, D.; LIU, M. T. Emulation of computer networks by microprogrammable microcomputers. June, 1974. 17p. (OSU-CISRC-TR-74-4) (PB-242 912/4GI)

BIERMANN, A. W.; KRISHNASWAMY, R. Constructing programs from example computations. August, 1974. 41p. (OSU-CISRC-TR-74-5)

BUTTELMANN, H. W. Semantic directed translation of context free languages. September, 1974. 36p. (OSU-CISRC-TR-74-6) (PB-242 854/AS)

HSIAO, D. K.; KAFFEN, N. E. A model for data secure systems (Part II). October, 1974. 40p. (OSU-CISRC-TR-74-7) (AD/A-006 276/0GI)

HSIAO, D. K.; KAFFEN, N. E. A model for data secure systems (Part III). November, 1974. 32p. (OSU-CISRC-TR-74-8) (AD/A-004 676/3GI)

HSIAO, D. K.; BAUM, R. I. Information secure systems. November, 1974. 55p. (OSU-CISRC-TR-74-9)

1975

HARTSON, H. R.; HSIAO, D. K. Languages for specifying protection requirements in data base systems (Part I). January, 1975. 61p. (OSU-CISRC-TR-74-10) (AD-006 280/2GI)

PETRY, F. E. Program inference from example computations represented by memory snapshot traces. February, 1975. 143p. (OSU-CISRC-TR-75-1)

MC CAULEY III, E. J. A model for data secure systems. March, 1975. 119p. (OSU-CISRC-TR-75-2) (AD/A-011 359/7GI)

HORGER, JR., W. A. Data base module verification--a certification method for data secure systems. June, 1975. 125p. (OSU-CISRC-TR-75-3)

RODEHEFFER, T.; KAFFEN, N. PREST4--A highly structured FORTRAN language for systems programming. July, 1975. 36p. (OSU-CISRC-TR-75-4)

WHITE, L. J.: SMITH, J. D.: KAR, G.; WESTBROOK, D. E.; BRINKMAN, B. J.; FISHER, R. A. A sequential method for automatic document classification. August, 1975. [134]p. (OSU-CISRC-TR-75-5)

HARTSON, H. R. Languages for specifying protection requirements in data base systems--A semantic model. August, 1975. 229p. (OSU-CISRC-TR-75-6) (AD-A018 284/0GI)

KAR, B. G.: WHITE, L. J. A distance measure for automatic sequential document classification. August, 1975. 160p. (OSU-CISRC-TR-75-7)

BAUM, R. I. The architectural design of a secure data base management system. November, 1975. 277p. (OSU-CISRC-TR-75-8) (AD-A021 158/1G1)

APPENDIX G

DOCTOR OF PHILOSOPHY DEGREE

1971

LANDRY, B. CLOVIS A Theory of Indexing: Indexing Theory as a Model for Information Storage and Retrieval.

1972

CAMERON, JAMES S. Automatic Document Pseudoclassification and Retrieval by Word Frequency Techniques

EKONG, VICTOR J. Rate of Convergence of Hermite Interpolation Based on the Roots of Certain Jacobi Polynomials

GORDON, ROBERT The Organization and Control of a Slave Memory Hierarchy

HARRIS DAVID R. GOLDA: A Graphical On-Line System for Data Analysis

MATHIS, BETTY ANN Techniques for the Evaluation and Improvement of Computer-Produced Abstracts

WEIMAN, CARL F. R. Pattern Recognition by Retina-Like Devices

WHITTEMORE, BRUCE J. A Generalized Decision Model for the Analysis of Information

1973

CHAN, PAUL SUI-YUEN An Investigation of Symetric Radix for Computer Arithmetic

DEFANTI, THOMAS A. The Graphics Symbiosis System - an Interactive Mini-Computer Animation Graphics Language Designed for Habitability and Extensibility

GELPERIN, DAVID H. Clause Deletion in Resolution Theorem Proving

HEPLER, STEPHEN PHILIP Use of Probabilistic Automata as Models of Human Performance

LAY, W. MICHAEL The Double-KWIC Coordinate Indexing Technique: Theory, Design, and Implementation

WANG, PAUL TIING RENN Bandwidth Minimization, Reducibility Decomposition, and Triangulation of Sparse Matrices

YOUNG, CAROL E. Development of Language Analysis Procedures with Application to Automatic Indexing

1974

BEUG, JAMES L. Human Extrapolation of Strings Generated by Ordered Cyclic Finite State Grammars

DOHERTY, MICHAEL E. A Heuristic For Minimum Set Covers Using Plausability Ordered Searches

GILLENSON, MARK L. The Interactive Generation of Facial Images on a CRT Using a Heuristic Strategy

LONGE, OLUWUMI An Index of Smoothness for Computer Program Flowgraphs

SU, HUI-YANG Pagination of Programs for Virtual Memory Systems

1975-76

BAUM, RICHARD I. The Architectural Design of a Secure Data Base Management System

DASARATHY, BALAKRISHNAN Some Maximu, Location and Pattern Separation Problems: Theory and Algorithms

HARTSON, H. REX Languages for Specifying Protection Requirements in Data Base Systems - A Semantic Model

JUELICH, OTTO C. Compilation of sequential Programs for Parallel Execution

KALMEY, DONALD L. Comparative Studies Towards the Performance Evaluation of Software for Solving Systems of Nonlinear Equations

KAR, GAUTAM A Distance Measure for Automatic Sequential Document Classification System

MOSHELL, JACK MICHAEL Parallel Recognition of Formal Languages by Cellular Automata

MUFTIC, SEAD Design and Operations of a Secure Computer System

PYSTER, ARTHUR B. Formal Translation of Phrase-Structured Languages

REAMES, CECIL C. System Design of the Distributed Loop Computer Network

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